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THE

AMERICAN JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. I.—*On Certain Meteorological Coincidences*; by J. H. Alexander, Esq.

That the phases of the Moon exercise no appreciable influence upon the weather, either as cause or concomitant, as agency or sign, is a dogma accepted and professed by most geometers and meteorologists, and, indeed, by savans generally; while the bulk of the unscientific portion of the community, and those whose pursuits are carried on chiefly in the open air, such as sailors, surveyors, agriculturalists, etc., are convinced that they trace a connection between the state of the Moon and state of the atmosphere, as real and hardly less constant and uniform than if it were predicted for them in a systematic theory.

I do not purpose to discuss the accuracy of these opposite views here; for which, there would be required a greater collection of observed material, and extending through longer periods than, I believe, the science of meteorology has yet been enriched with, and also individual faculties of learning, acuteness, and patience, in an excellent and rare degree.

But I may remark in passing that, with most persons, the scientific denial above mentioned is probably limited, in fact as in terms, to the *appreciability* of the influence in question with our means of observing, not to the actuality or possibility of the influence itself. At least such would most likely be the position taken upon reflection. For it would be hard to deny that the pulses and tides of the atmosphere are less harmoniously linked in with planetary attractions, or less under the domain of the principle of universal gravitation, than the tides of the ocean or the

motions of bodies still more dense. And it would be difficult to discredit the anticipation that, one day, Meteorology is to become more a science of calculation than it is at present; and that, then, phenomena, which as yet appear arbitrary or insignificant, will be recognized as elements in great normal formulæ, each term of which will be continually becoming more distinct and better known, until, as far as finite faculties allow, we approach that divine geometry of which Plato dreamed, and which cannot but be prescient since it knows the structure and conditions of existence and relations of all things.

But, without ascending to such lofty generalities as these, it might perhaps be even claimed by the believers in prognostics, that certain observations have been already made and discussed by sceptical philosophers,* whose normal occurrence may be affirmed with a high degree of probability; and which, although incapable as yet of being derived from, or bound in with, a sound theory, seem fully to deserve the character of *coincidences*. It is by such a term, not more modest than appropriate, that I prefer to designate the accordances that I have observed, and which this paper is intended to indicate.

These observations and the conclusions from them are not of recent origin; although, in so far, they do not rest upon regularly recorded and tabulated results. Years ago, when the enjoyment of weekly half-holidays was dependent more or less upon the state of the weather, it was of interest to me to have some means of prognosticating that state; and I watched and treasured up all indications which might serve to that end, until I came at last to the conclusion warranted by frequent experience, that *the third day before the New-moon regulated the weather on each quarter-day* of that lunation, and also *characterized the general aspect of the whole period*. Thus, if the New-moon happened on the 26th May, 1824, the term-day was the 24th May; the weather on which 24th May determined what was to be on the 26th May, and on the 3d, 11th and 19th June, the quarter-days, respectively, of that lunation.

Lately, upon an accidental reference to these coincidences, in conversation with certain friends who had paid much attention to the subject, an interest was expressed to have this supposed rule tested by some past systematic observations. Accordingly, I availed of my first leisure to resort to the daily meteorological observations at the Girard College, Philadelphia; and the accordance of these with the proposed rule and the consequent probability of that rule, are all that remain to be stated here.

These observations were made under the direction of Professor Bache, now the Superintendent of the Coast Survey of the United States; and have, both in the character of their Director and their own intrinsic evidence, all guarantee of their reliability. They ex-

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* Arago: *Ann. du Bureau des Longitudes*, 1833.

tend altogether from June, 1840, to June, 1845, inclusive; comprehending 62 entire lunations or 248 epochs of possible coincidence.

These were not only *daily* observations, but for the greater part *hourly* observations even, of various particulars interesting to meterology. Of these, all that have been taken into account at present are those that relate to the aspect of the sky and character of the clouds; the density, moisture, temperature, etc., of the atmosphere, which bear only collaterally upon the point in question, may be as yet pretermitted.

A part of the time, the observations were not at such short intervals; and for four months in 1843, they were irregular. Also, during the whole series, observations were systematically omitted on Sundays: which day of the week, however, was of course sometimes the term-day and sometimes the quarter-day of a particular lunation. Owing to these circumstances, the series, for the purpose of this comparison, comes to be grouped as follows, viz:

(*a*)	:	31	lunations;	in which all the days are given;	
(*b*)	:	12	do.	in which *one* quarter-day is missed;	
(*c*)	:	6	do.	do. *two* quarter-days are missed;	
(*d*)	:	1	do.	do. *three* do.	
(*e*)	:	1	do.	do. *four* do.	
(*f*)	:	7	do.	in which the term-day is missed;	
(*g*)	:	4	do.	in which observations were not regular.	
		62	lunations;	covered by the series. Excluding the last three groups	
of . . .		12	lunations,	we have left	
		50	lunations,	suitable for comparison and whose results are given here.	

The method used in this comparison is much more stringent than in the observations upon which the supposed rule originally reposed. In these last, the range of the entire day (i. e., daylight) was allowed to verify the coincidences without respect to the precise *hour* of the day when the change of Moon occurred. And the same range (or looseness, if any one prefers to term it so) might even have been admitted now. But I preferred, for various reasons which need not be dwelt on, to observe the coincidences at the precise hours of change. The following extract from the note book in which the comparisons were copied from the printed Girard observations, and where, close together, come one of the accordant cases, and one of the most discordant, will exemplify, better than any description, the mode pursued.

Date.	Epoch.	Sky covered 10ths.	Clouds, etc.	Results.	
1843, May 27, 2h. M.	Term-day,	1·0	N., raining.		
29, 2h. M.	●	1·0	N., raining,		
June 5, 9h. M.	◐	1·0	Ci-cu., Cu.	accord't.	discord't.
12, 2h. A.	○	1·0	Cu-s.	≠ 1.	b 3
19, 3h. A.	◑	0·7	Cu.		
25, —	Term-day,	—	——	missed.	
July 25, 1h. M.	Term-day,	0·9	Hazy, Cu.		
27, 1h. M.	●	0·3	S. at hor.		
Aug. 2, 6h. A.	◐	1·0	Cu-s., Cu.	accord't.	
9, 11h. A.	○	0·3	Ci., Ci-cu., Ci-s., S.	≠ 4.	
18, 2h. M.	◑	—	Clear.		

Of these columns, the first, third and fourth are mere transcripts of the printed observations; with the hours of ☾'s change (morning or afternoon) supplied to the first column. The second and fourth belong to the comparison. It is to be observed, farther, that the supposed rule claimed no more than the distinction between *dry* and (as it is called) *falling* weather. Thus, the existence of nimbus or rain-cloud on any quarter day, *provided it did not rain*, might be taken as coinciding with the weather on a term-day which was *clear*. But I have not so taken it, in fact; and have reckoned the existence of nimbus as equivalent to rain, and noted it as accordant or discordant, as the case may be. However hardly this may strain the supposed rule, I have no doubt of the soundness of its being insisted on. On the other hand, the propriety of considering the weather on 18th Aug., 1843, as coincident with the weather on 25th July, 1843, for instance, will, I suppose, be equally admitted.

With this exposition of the principles and manner of the comparisons, of which throughout the extract above is an average sample, the aggregate results may now be stated.

Of the 31 lunations, then, contained in group (*a*),

16 agree throughout,
8 miss *once*,
4 miss *twice*,
2 miss *thrice*,
1 disagrees throughout.

31 in all.

If I were endeavoring to sustain the supposed rule, *coûte qui coûte*, as a matter of argument or opinion, instead of honestly seeking for information, the uniformity of bisection in this last series and the correspondence between the numbers and characters of the discordances, might be plausibly urged according to the received doctrine of probabilities as being of great weight.

Of the 12 lunations in group (*b*),

7 agree throughout,
5 miss once.

12 in all.

Of the 6 lunations in group (*c*),

5 agree throughout,
1 misses twice.

6 in all.

The single lunation, classed (*d*), which contains but one quarter-day, misses.

In lunations, then, there are under

(*a*)	16	accordant entirely;	15	discordant more or less;
(*b*)	7	do.	5	do.
(*c*)	5	do.	1	do.
(*d*)	0	do.	1	do.
	28	accordant throughout;	22	discordant more or less;

and the chances would be in every 100 times, 56 in favor of the supposed rule and 44 against it; or the final probability would be 1,27, etc.: 1, for the rule.

But this comparison by lunations is defective; inasmuch as it does not allow a distinction in the character and degree of the discordances. For this, as well as for the proportion of missing observations, it is better to make comparison by the actual *epochs* or quarter-days; designating separately the aggregate number of those which coincide with the term-days, of those which differ, and of those which have failed to be observed at all. Of course, every such epoch affords occasion for a coincidence; and in proportion to the number of actual coincidences out of a given number of such occasions will be the probability of the supposed rule.

Counting, then, by epochs, the aggregate are as under:

	Accordant.	Discordant.	Not Observed.
(*a*) . .	98	26	0
(*b*) . .	31	5	12
(*c*) . .	10	2	12
(*d*) . .	0	1	3
	139	34	27

If we leave the epochs *not observed* out of the question, the chances stand as rather more than 4 to 1 in favor of the rule; or its probability is a little more than $\frac{4}{5}$.

If we consider that among those unobserved epochs the chances of coincidence are even, then they will stand as 76·25 out of 100 in favor of the rule; or its probability is rather more than $\frac{3}{4}$. The lowest of these probabilities is greater than is sometimes taken as sufficient ground for human belief or human actions.

I may terminate this notice in the words of Carlini upon a similar occasion:* "Queste conclusioni non devono considerarsi ..... come quelle che converebbe dedurre dal paragone delle osservazioni continuate per un gran numero d'anni. Ciò nulla ostante, non ci è sembrato del tutto inutile il presentar quì i risultati delle poche osservazioni delle quali potevamo far uso; sperando che da essi possa trarsi qualche norma par istabilire un piano generale d'osservazioni meteorologiche che riesca il più opportuno allo studio de' fenomeni atmosferici."

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* *Sulla Legge delle Variazoni Orarie del Barometro*, etc., Modena, 1848.

ART. II.—*On a Method for distinguishing between Biaxial and Uniaxial Crystals when in thin plates,—and the results of the examination of several supposed Uniaxial Micas;* by W. P. BLAKE. (Read before the American Association for the Advancement of Science, at Cincinnati, May, 1851.)

THE greater number of the "black micas" so-called, have a deep olive green or "bottle green" color, so deep as generally to be opaque when the thickness exceeds one-fourth of a millimetre.* The other colors most frequently observed are a dull brownish green, sometimes yellowish, and a fiery red. Of course their power of absorbing light varies greatly; thus, the mica from

Greenwood Furnace, olive green, is opaque in plates over		·500 mm. thick.
Sussex Co., N. J., (No. 115) bottle green,	" " " "	·222 "
St. Lawrence Co., (No. 116) brownish	" " " " "	·062 "
" (No. 113) olive green,	" " " "	·042 "

These thicknesses were taken with an instrument constructed by Soleil, for measuring the thickness of thin plates.† It is called a spherometer and was designed by M. Cauchoix.

In stating the color of specimens, I have given that color which they present when a plate sufficiently thin to be transparent is held near the eye, while the light from the clouds or window is allowed to pass through it. It is not therefore possible to examine plates of these micas in the ordinary way, even when the thickness is less than stated above; and of course when so very thin, the images formed around the pole or poles of the resultant axes, are much extended and it would generally be impossible to distinguish them or the dark bars which cross the center; and when they can be seen, they so nearly resemble the symmetrical image formed in uniaxial crystals that they cannot be distinguished from them.

In order to enable me to give these dark micas a more complete and thorough examination, I have arranged, in addition to the combination of lenses and "Nichols Prism," which I described at the meeting of the American Association last August, a large convex lens, placed between the polarizing mirror of my instrument and the film of mineral to be examined; I also use, instead of the variable and uncertain light from the clouds, a broad gas flame, which I bring near to the mirror, so that its reflected image is condensed by the large convex lens upon the mica; with this arrangement I have been able to discern the *rings* and *cross* in plates of the dark micas much thicker than could be examined by any former arrangement. It now became interesting to examine some of the micas whose optical uniaxial character was equivocal, and for this purpose I adopted the following test.—

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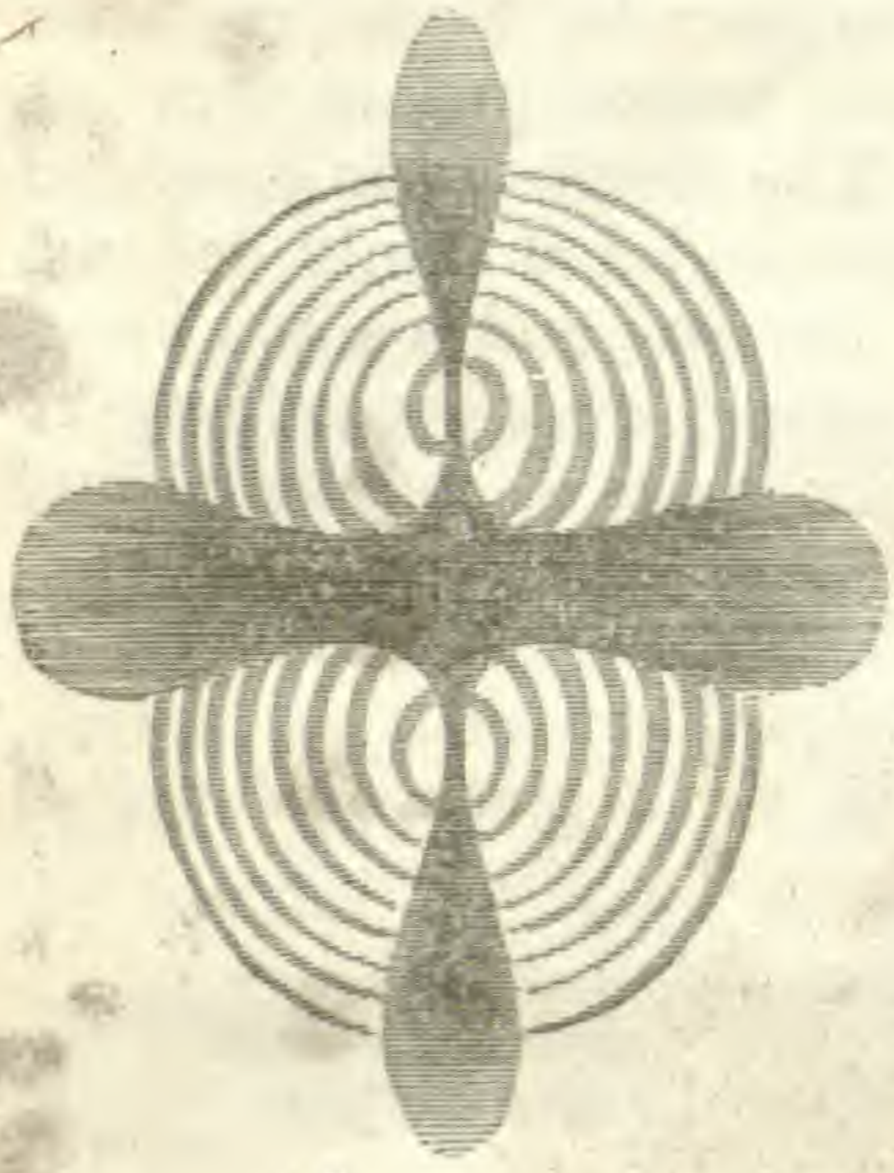
* Ordinary visiting cards are from ·3 to ·4 of 1 mm. thick.

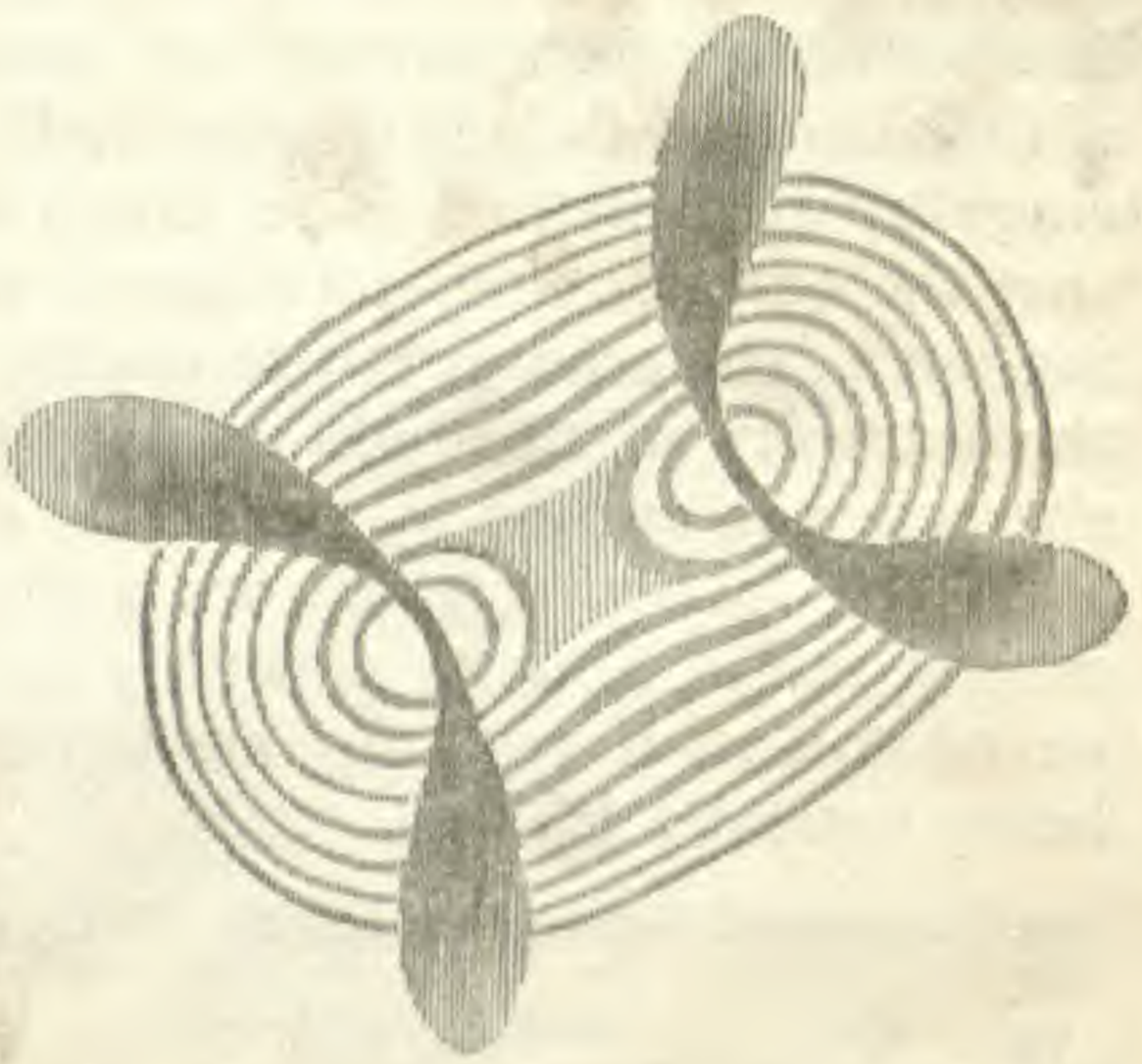
† Described in E. Peclet's Traité de Physique, 4e ed. Paris, 1847, i, 5.

It is well known that where a plate of Iceland-spar, cut with faces perpendicular to the axis, is placed in a polariscope (the eye-piece being "crossed") and then rotated in its own plane, the symmetrical cross and rings do not suffer any change of form or position, if, however, a plate of a biaxial crystal—as nitre—be rotated in a similar manner, the dark bars which form the cross, as in fig. 1, will, when the plate has been rotated 45°, "open out," and take the form and position represented in fig. 2. These

1.



2.



3.

4.

facts and figures, though familiar to the student of optics, I here repeat for the sake of the explanations which follow; and this is particularly important since observers of eminence have evidently mistaken the optical character of many of the so-called *uniaxial* or *hexagonal* micas. When the micas referred to are examined by my instrument I find the same evidence of a *biaxial* character. The thin plates, if the line joining the poles is parallel to the plane of primitive polarization, give to the eye symmetrical crosses and rings, as in fig. 3, that is, so *nearly symmetrical* that it is

hardly possible to distinguish any variation from symmetry, and such crosses might be taken as proof of a uniaxial character. But on rotating 45°, as in the case of the nitre crystal, we lose the symmetrical form of the cross, which opens out, as represented in fig. 4. This deportment of the cross may be observed when, owing to the depth of color, it is not possible clearly to discern the rings.

A method given by Müller* also depends upon this deportment of the dark bars; it consists in rotating the plate of mica when on the table of M. Noremberg's apparatus (the ray being extinguished by the eye-piece); if the mica be biaxial the light is alternately, for every 45° of rotation, transmitted or shut off, if *uniaxial*, no change is perceived. The image of the cross and rings by this method is so much extended and dimly defined, that the outlines cannot be traced by the eye, and a slight opening-out of the cross is not so readily noticed, even by a change in the intensity of the light, as when its image is contracted and sharpened in outline by the action of lenses.

In the following table are given the localities and color of several micas hitherto generally considered uniaxial, but which, on examination with my arrangement, have given evidence of being optically *biaxial.*

76. Greenwood Furnace, Orange Co., N. Y.; olive green; rhombic plates.†
77. " " " " " second specimen.
79. " " " " " third specimen.
86. Easton, Pa.; a white silvery mica.
88. Topsham, Maine; fine crimson red.
89. Mount Vesuvius; dark green.
101. " " " " Another specimen; clearly biaxial.
105. " " " " A thicker plate of specimen 101; clearly biaxial.
102. " " transparent, with delicate shade of green; banded with bands of a deep green, meeting at angles of 60°.

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* Lehrbuch der Physik und Meteorologie, Braunschweig, 1844, p. 588.

† Greenwood furnace is in the town of Monroe, and this is the Monroe mica, analyzed by von Kobell (Kastn. Arch., xii, 29, and Dana's Min., 3d edit., 360) and pronounced by him on optical grounds to be uniaxial, it giving a symmetrical cross. It afforded the chemical formula $\dot{R}^3\,\ddot{S}i + (\ddot{A}l, \ddot{F}e)\,\ddot{S}i$, corresponding to the oxygen ratio for the protoxyds, peroxyds and silica 1 : 1 : 2. The exact ratio as worked out by Rammelsberg is 10·4 : 9·8 : 20·78, while the Vesuvian mica gave 10·1 : 10·0 : 20·65, and one from Bodenmais 10·25 : 10·96 : 21·23. The ratio is in fact the general ratio of the so-called "*hexagonal*" micas or Biotites. In the Greenwood furnace mica, we have evidence therefore that one at least of these Biotites is not hexagonal; and the same we believe true for some of the "hexagonal" Vesuvian micas. The importance of a revised crystallographic examination of these micas is hence obvious. The mica of Greenwood furnace is of a blackish green color, and occurs usually in very acute oblique prisms, often of very large size; angle of prism (M : M) 71° to 72°, it being oblique from an *acute* edge, and not from an *obtuse* edge as in ordinary biaxial mica. The angle between the base and a lateral plane (P : M) is 66°–67° and 103° to 114°, according to the writer's measurement. The replacement of the acute solid angle reduces the form to a rhombohedron with a basal cleavage plane, and thus it was taken by von Kobell. The faces of the crystals are so imperfect that the discrepancies obtained are usually one degree, on similar parts of the same crystal. Another Monroe mica (No: 81 above) is the only other mica which could possibly have been Kobell's, and that too is proved by Mr. Blake to be biaxial. J. D. D.

103. Mount Vesuvius; from same specimen as 102, but thicker; biaxial.
104. " " from same specimen, still thicker; gives good elliptical image.
142. " " beautiful green, like No. 101, is in small hexagonal crystals and associated with Idocrase.
111. Franklin Furnace, Sussex Co., N.J.; deep copper red; G.J. Brush to B. Silliman, Jr.
109. St. Jerome, Canada; coppery, reddish; angle, estimated 10°.
114. Moors Slide, Ottawa, Canada; dark bottle green; T. S. Hunt to B. Silliman, Jr.
116. St. Lawrence Co., N. Y.; dark brownish green; opaque, over ·062 mm. thick.
84. Hammond, St. Lawrence Co., N. Y.; rich smoky yellow; from Saml. W. Johnson.
68. " " dark brownish red; black by reflected light.
106. Gouverneur, N. Y.; (boulder) dark brown.
81. Monroe, Orange Co., N. Y.; dark green.
108. " " dark bottled-green; from S. R. Horton to B. Silliman, Jr.
107. Locality —— ? Cambridge Cabinet; rich brown; in beautiful rhombic plates;
112. Locality —— ? Cambridge Cabinet; deep green; like Greenwood Furnace mica.
63. Moriah, Essex Co., N. Y.; fiery red; Lederer Cabinet; angle measurable.
139. Warwick, Pa.; olive green (brownish); angle estimated over 10°; this much resembles the Vesuvius specimens, Nos. 102 and 103.

With the exception of the dark micas mentioned in the following table, I have not yet examined any that do not give evidence of being optically *bi*axial; and, it is probable, that these exceptions would give the modifications of the cross, &c., if their dark color did not make it impossible to observe them in plates sufficiently thick. But if biaxial, the angle for the mica of Sussex, New Jersey, No. 115, must be very small.

98. Locality —— ? dark olive green; resembles No. 81.
83. Locality —— ? Yale Coll. Cabinet; color intensely green.
115. Sussex Co., N. Y.; dark green; opaque when in plates over ·222 of 1 mm. thick.
113. Locality —— ? N. Y. Lyc. Nat. Hist.; opaque in plates over ·042 mm. thick.
148. Middletown, Ct.; very dark green.
146. N. Y. Island; very dark olive-green; in granite veins traversing gneiss.
147. " " " " "

To Prof. B. Silliman, Jr., I am indebted for the free use of his specimens for these investigations: the biaxial character of many of them was suspected by him, when he first examined them, as is mentioned in his communication in this Journal, vol. x, November, 1850.

In specimens of mica referable to the species Phlogopite, having the inclination of the resultant axes between 5° and 20°,—when the thickness is so much reduced that the systems of rings around poles are not distinctly separated, the angular inclination of the axes cannot be determined in the ordinary manner. Further observations upon this point I reserve for a future communication.

ART. III.—*On some of the Thermal Waters of Asia Minor;* by Dr. J. LAWRENCE SMITH, of New Orleans, Prof. Chem. in the University of Louisiana.

Part I.—*The Thermal Waters of Broosa.*

THERE are few countries where Thermal Waters are so numerous, and cover so extensive a surface as in Western Asia Minor; many of them still bear marks of the estimation in which they were held by the ancient Romans and Greeks for the purpose of supplying their baths.

Owing to the difficulty of obtaining proper vessels or corks at or near the springs, coupled with the risk of breakage by the necessary transportation on the backs of horses over rough and mountainous roads, travellers have been deterred from collecting these waters for the purpose of analysis. In my travels through certain parts of this country, I took along with me bottles and corks, and collected between twenty and thirty specimens of different localities, some of them in considerable quantity; and of that number fifteen or sixteen have arrived safely to my laboratory, where most of them have been already examined.

In my remarks upon them I will first allude to the thermal waters of Broosa or Prusia, which are the most important at the present day, and the most accessible from Constantinople. The spot itself is hallowed by many interesting historical associations. The city was founded by Hannibal during a friendly visit which this great Carthagenian general made to Prusias, the king of Bythinia, whose name was given to it. Like all other cities of so ancient date, it has gone through many changes, passing successively into the hands of the Greeks, Romans, and Turks. Since 1326 the Turks have continued masters of this part of Asia Minor, it having been conquered by Osman just prior to his death, for many years after which event it remained the capital of the Ottoman empire.

Broosa is readily reached from Constantinople by a steamer that goes from this latter place to Modania, on the gulf of the same name, about seventy miles from Constantinople. From Modania a ride of about twenty miles on horseback brings you to Broosa, at the foot of the Bythinian Olympus. The warm baths of this place have been celebrated from the earliest epochs, and the visit of Constantine with his wife in 797, is recorded in history as having resulted favorably in restoring the latter to health. And at a still later period Sultan Soleman the Great visited these baths on account of an attack of gout, and to commemorate his cure he had a large dome constructed over the source to which he attributed the beneficial effects derived by him; the dome still stands.

As it is not my object to enter here into the details of baths well known to all travellers in this part of Asia Minor, I shall at once proceed to the description of the sources. The sources of thermal waters near Broosa are seven in number, all situated in a little valley which separates *Mount Olympus* from *Mount Katairli*, and they are comprised within the distance of a mile and a half. In the immediate neighborhood of some of these sources, and sometimes in direct proximity, are sources of cool and delightful water that serve to regulate the temperature of the water used in the baths, of which there are as many as twenty private and public. These sources furnish waters of two description, the sulphurous and the non-sulphurous, and I shall commence with a description of the former.

THERMAL SULPHUR WATERS.

There are two sources of this class of water near Broosa, or rather two places near to each other where it flows out of the mountain, for my examination goes to prove that they are the same water. Their names are *Kukurtlu* and *Bademli-Baghtsche.*

Kukurtlu Source.

The name of the source signifies sulphur. It flows rapidly from the side of the mountain near to its base, through a bed of calcareous tufa, furnishing upwards of twenty gallons a minute, which, along with the water from a cold spring near by, is made to flow through the baths. There is a very sensible odor of sulphuretted hydrogen proceeding from the water of this source, more especially as it issues forth from the mountain, for there is a large amount of gas bubbling through the small reservoir into which the water rises, accompanied with a larger amount of vapor. As the water flows it leaves an incrustation of carbonate of lime, more or less colored with some organic matter. This source is held in particular veneration by the Greeks of the country, who usually assemble here twice a year to commemorate the martyrdom of St. Patrice, which was ordered by the Pro-consul of Broosa, and executed by his being thrown into this almost boiling spring.

The country is *geologically* made up of the older rocks, as granite, gneiss, limestone, &c., a silicious variety of the latter overlying the other two; in some parts, however, the limestone is remarkably pure, and has doubtless furnished to these waters that carbonate of lime so extensively deposited at the base of this part of the mountain in the form of tufa, which, for a mile or two of extent, rises several hundred feet above the plain at the foot of the mountain.

Physical Properties.—The water as taken from the source is perfectly clear and transparent, and remains so when kept in well corked bottles, but otherwise a yellow deposit is soon formed which

is probably crenate of lime. A slight odor of sulphuretted hydrogen, not perceptible when the water is cold. The taste of the water when cold is in no way peculiar, and it is very pleasant to drink. Specific gravity 1·00118. Temperature, (atmosphere at 66° Fah.,) 182° Fah., which varies but a few degrees with the seasons.

Chemical Composition.—The *gas* which escapes from the source was collected in inverted bottles, well corked and sealed, and in one thousand parts was found to contain—

Carbonic acid, ...	886
Nitrogen, ...	99
Oxygen	11
Sulphuretted hydrogen, ...	4

Solid contents in one litre of the water, 970 grammes. The water is alkaline, and, when concentrated to one third its bulk, gives a very sensible alkaline reaction with reddened litmus paper. It is found to contain the following ingredients in one litre:

	Grammes.		Grammes.
Carbonic acid, free,* .	·3420	Lime, . . .	·1415
Carbonic acid, fixed, .	·1820	Magnesia, . . .	·0142
Hydro-sulphuric acid, .	·0012	Alumina, . . .	·0012
Sulphuric acid, . .	·2140	Silica, . . .	·1100
Chlorine, . . .	.0103	Iron, ...	trace
Soda, . . .	·2600	Organic matter (crenic acid),	·0350
Potash, . . .	·0110		

These acids and bases may be represented as combining in the following manner:

Bi-carbonate of soda, .	.4100	Sulphate of alumina, .	·0043
Bi-carbonate of lime, .	·1830	Chlorid of sodium, .	·0170
Bi-carbonate of magnesia,	·0460	Hydro-sulphate of soda,	·0033
Sulphate of soda, .	·1950	Carbonate of iron, ·	trace
Sulphate of potash, .	·0202	Silica, . . .	·1100
Sulphate of lime, .	·1710	Organic matter, . .	·0342

The incrustation from this spring was next examined. One gramme of a beautiful crystalline portion was analyzed and found to contain—

Carbonate of lime, .	·970	Silica, ...	003
Carbonate of magnesia,	·016	Organic matter, . .	trace
Sulphate of lime, . .	·008	Fluorid of calcium, .	trace
Peroxyd of iron, . .	·011		

There are some portions of the incrustation richer in organic matter than this, but then the mixture is sensible to the eye, and does not represent the pure crystalline deposit of the spring.

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* What is here meant, is, such of the carbonic acid as can be expelled in boiling the water.

The *Kukurtlu* source supplies two baths with water, one called the *Buyuk Kukurtlu* and the other the *Kutschuk Kukurtlu.*

The other source of sulphur thermal water is called—

Bademli Baghtsche.

This source is about three hundred feet from the latter, and flows from three or four openings in the tufa. On my visit to it the entrance to the sources was closed up with masonry, and the door could not be opened by the Turks from some superstitious motive. I was, however, enabled to procure the water a few feet from the source as it flowed through an open gutter; gas is said to escape abundantly from the source, just as in the Kukurtlu source.

Physical Properties.—It is clear and transparent, remaining so in well corked bottles; exposed to the air it gradually becomes cloudy, and deposits a yellowish sediment. Has a slight odor of sulphuretted hydrogen when warm. Specific gravity 1·00116. Temperature, (atmosphere at 67°,) 184° Fah.

Chemical Composition.—Solid contents, ·978 grammes in one litre. The water when concentrated reacts strongly alkaline. In one litre there are the following ingredients in grammes:

Carbonic acid, free, .	·2920	Lime, . . .	·1378
Carbonic acid, fixed, .	·1875	Magnesia, . . .	·0160
Hydro-sulphuric acid, .	·0010	Alumina, . . .	·0005
Sulphuric acid, . .	·2160	Silica, . . .	·1100
Chlorine, . . .	·0112	Iron, ...	trace
Soda, ...	·2650	Organic matter (crenic acid?), . .	·0402
Potash, . . .	·0130		

The combination of the acids and bases may be represented in the following manner:

Bi-carbonate of soda, .	·4070	Sulphate of alumina, .	·0020
Bi-carbonate of lime, .	·1790	Chlorid of sodium, .	·0192
Bi-carbonate of magnesia,	·0520	Hydro-sulphate of soda,	·0019
Sulphate of soda, .	·2000	Carbonate of iron, .	trace
Sulphate of potash, .	·0225	Silica, ...	·1100
Sulphate of lime, .	·1660	Organic matter, . .	·0402

Two baths are also supplied from this source, the one called *Yeni-Kaplidja* and the other *Kainardja.*

It will be seen that in physical properties and chemical composition, the water of this source is identical with that of Kukurtlu; at which fact I was at first somewhat surprised, as an approximate analysis made some years ago by Dr. Bernard led me to look for a difference in the composition of these waters; and it was not until my analysis was completed that I became convinced that the waters of the Kukurtlu and Bademli-Baghtsche sources were the same, making its way through different openings in the tufa. I would merely remark here, that the an-

alysis made by Dr. Bernard must have been quite crude, as among other things he gives to a litre of the Kukurtlu water ·332 grammes of sulphuretted hydrogen, water which, when cold, has no hepatic odor, and has hardly a sensible effect on lead water.

None of the other sources near Broosa evolve a trace of sulphuretted hydrogen, and contain less solid matter; they are all alkaline, and give an alkaline reaction when concentrated.

THERMAL ALKALINE WATERS.

Of the alkaline waters, I have examined three sources situated at some distance from each other.

The *Kara Mustapha* source is about two hundred yards from the *Kukurtlu*, and almost on the border of the plain of Broosa; it supplies a bath bearing the same name.

Physical Properties.—Clear when taken from the source and kept in well stopped bottles. As the opening in the mountain from which it escapes is bricked over, it was impossible for me to ascertain if there were an abundant escape of gas. Temperature, 127° Fah. Specific gravity 1·00094.

Chemical Composition.—Solid contents in one litre ·541 grammes, and the same quantity of the water contains—

Carbonic acid, free,	·104	Lime,	·115
Carbonic acid, fixed,	·150	Magnesia,	trace
Sulphuric acid,	·068	Iron,	trace
Chlorine,	·005	Silica,	·066
Soda,	·132	Organic matter,	not estimated.

The combinations of the acids and bases may be represented as follows, in grammes:

Bi-carbonate of soda,	·2600	Chlorid of sodium,	·0084
Bi-carbonate of lime,	·2380	Carbonate of iron,	trace
Sulphate of soda,	·0452	Silica,	·0660
Sulphate of lime,	·0670	Organic matter,	not estimated.
Carbonate of magnesia,	trace		

Incrustations of carbonate of lime are deposited from this source, but not so abundantly as from the two first mentioned.

Tschekirghe Source.

The Tschekirghe source is about a mile and a half from Broosa, and supplies four baths, those of *Boigusel*, *Vani*, *Tschekirghe*, and *Yeni-Han*.

Physical Properties.—Clear, and does not readily deposit a sediment; the incrustation much less than at the other sources. No gas escapes from it as it flows from its source. Temperature, (air at 72° Fah.,) 113° Fah. Specific gravity 1·00068.

Chemical Composition.—Solid contents in one litre ·550 grammes; the same amount of the water contains—

Carbonic acid, free,	·040	Lime,	·168
Carbonic acid, fixed,	·094	Magnesia,	trace
Sulphuric acid,	·152	Iron,	trace
Chlorine,	trace	Silica,	·040
Soda,	·039	Organic matter,	not estimated.

Combined as—

Bi-carbonate of lime,	·2336	Sulphate of lime,	·2190
Carbonate of soda,	·0480	Chlorid of sodium,	trace
Carbonate of magnesia, } Carbonate of iron, }	traces	Silica,	·040
Sulphate of soda,	·0250	Organic matter,	not estimated.

The last source that I shall allude to is a very small one near to the *Kukurtlu*, and not connected with any bath, it is, however, used by the natives for the treatment of diseased eyes.

Gueuzayasma Source.

The Gueuzayasma source rises slowly in an excavation in the side of a rock, no gas whatsoever escaping from its surface; an incrustation is formed from it, that is in some places covered with a thin green coat resembling some of the salt of nickel or copper, it is, however, entirely of a vegetable character, and exhibits under the microscope a beautiful lace structure.

Physical Properties.—Clear and transparent; Temperature, 113° Fah. Specific gravity, 1·00122.

Chemical Composition.—Solid contents in one litre, ·901 grammes. One litre of the water contains—

Carbonic acid, free,	·220	Lime,	·175
Carbonic acid, fixed,	·150	Magnesia,	trace
Sulphuric acid,	·215	Iron and alumina,	trace
Soda,	·151	Silica,	·114
Potash,	·006	Organic matter,	not estimated.

Combined as follows:

Bi-carbonate of soda,	·2405	Sulphate of lime,	.2370
Bi-carbonate of lime,	·2249	Sulphate of alumina,	trace
Bi-carbonate of magnesia, }	strong trace	Carbonate of iron,	trace
		Silica,	·1140
Sulphate of soda,	·1160	Organic matter,	not estimated.
Sulphate of potash,	·0110		

The incrustation of the spring contains 97 per cent. of carbonate of lime, the remainder is composed of carbonates of iron and magnesia and the sulphate of lime without a trace of fluorine.

These various springs it will be seen supply nine public baths, which vary in their size and magnificence, that of *Yeni-Kaplidja* being the largest and most beautiful; they are constructed on the usual plan of the Eastern baths, and consist of three parts:

First, a large hall, with an elevated platform all around two feet high, and sometimes galleries attached. It is on the platform that one disrobes himself prior to entering the bath, and it is also here that the bather reposes on a couch in retiring from the bath. This apartment is frequently ornamented with considerable luxury; it is well lighted, and there is sometimes in the middle a fountain, the falling of whose waters in the basin produces a freshness, and at the same time invites to slumber. This apartment is called by the Turks *Djamekian* (Vestiarium).

The next division in the bath is the *Sooukklouk*, where one begins to experience the temperature of the inner bath, and where he reclines on a marble slab, and is either shampooed or places himself in the hands of the barber to be shaved, cupped or bled.

The third division is the *Hammam*, or bath properly speaking, where there is an atmosphere of 105° to 110° Fah., filled with the vapor of water arising from the heated marble floor. Here there are various recesses with small marble basins in which streams of hot and cold waters are allowed to flow; and once seated by one of them, an attendant of the bath takes possession of you, and puts you through a series of operations that can be better felt than described. The baths at Broosa have usually in the *Hammam* a large basin of hot water, into which the bathers can plunge, the one in the *Yeni-Kaplidja* is about five feet deep by thirty in diameter.

There is in some of these baths a small room called the *Boghoulouk* (Sudatorium), where the temperature is from 120° to 130° Fah. Once through the various operations of the bath one returns to the first room, reclines on a bed and indulges for a half hour or more in the Eastern luxuries of smoking and drinking coffee or sherbet.

This is a hasty sketch of the operations that the bather usually undergoes at these baths; but as numbers of invalids visit them, arrangements are made by which they can bathe in whatsoever way they may think best or the physician prescribe, for there are private apartments attached.

These thermal waters are in great repute in Turkey, and their effects are said to be most marked on chronic irritation of the abdominal organs; chronic rheumatism; gouts; chronic irritation of the mucus membrane of the intestines; diseases of the bladder, of the skin, and of the eyes, &c. These waters are also recommended to be taken internally when cold.

In the calcareous incrustation of three of these springs that were examined, I found the remains of two or three varieties of silicious infusoria after the lime had been dissolved out by an acid.

Some few remarks that I have to make with reference to the chemical analysis of these waters will be deferred until the publication of the second part of this paper.

New Orleans, March 14th, 1851.

Art. IV.—*Uses of the Stillingia sebifera or Tallow Tree, with a notice of the Pe-la, an Insect-wax of China :** By J. D. Macgowan, M.D.

The botanical characters of this member of the Euphorbiacæ are too well known to require description ; but hitherto no accurate account has been published of its varied uses, and although it has become a common tree in some parts of India and America, its value is appreciated only in China, where alone its products are properly elaborated. In the American Encyclopedia it is stated that this tree is almost naturalized in the maritime parts of South Carolina, and that its capsules and seeds are crushed together and boiled, the fatty matter being skimmed as it rises, hardening when cool.

Dr. Roxburgh in his excellent *Flora Indica*, says : "It is now very common about Calcutta, where in the course of a few years, it has become one of the most common trees. It is in flower and fruit most parts of the year. In Bengal, it is considered only an ornamental tree ; the sebaceous produce of its seeds is not sufficient in quantity, nor its qualities so valuable, as to render it an object worthy of cultivation. It is only in very cold weather that this substance becomes firm ; at all other times it is in a thick brownish fluid state, and soon becomes rancid : such is my opinion of the famous vegetable tallow of China."

Dr. Roxburgh was evidently misled in his experiments by pursuing a course similar to that which is described in the Encyclopedia Americana, (and in many other works,) or he would have formed a very different opinion of this curious material.

Analytical chemistry shows animal tallow to consist of two proximate principles—*stearine* and *elaine*. Now what renders the fruit of this tree peculiarly interesting is the fact that both these principles exist in it separately, in nearly a pure state. By the above named process, stearine and elaine are obtained in a *mixed* state, and consequently presents the appearance described by Dr. Roxburgh.

Nor is the tree prized merely for the stearine and elaine it yields, though these products constitute its chief value ; its leaves are employed as a black dye ; its wood being hard and durable may be easily used for printing blocks and various other articles, and finally, the refuse of the nut is employed as fuel and manure.

The *Stillingia sebifera* is chiefly cultivated in the provinces of Kiangsi, Kougnam, and Chehkiang. In one district, near Haugchan, the inhabitants defray all their taxes with its produce. It grows alike on low alluvial plains and on granite hills, on the

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* Drawn up for the Agricultural and Horticultural Society of India.

rich mould at the margin of canals, and on the sandy sea beach. The sandy estuary of Haugchan yields little else; some of the trees at this place are known to be several hundred years old, and though prostrated, still send forth branches and bear fruit. Some are made to fall over rivulets, forming convenient bridges. They are seldom planted where any thing else can be conveniently cultivated—in detached places, in corners about houses, roads, canals, and fields. Grafting is performed at the close of March, or early in April, when the trees are about three inches in diameter, and also when they attain their growth. The Fragrant Herbal recommends for trial the practice of an old gardener, who instead of grafting, preferred breaking the small branches and twigs, taking care not to tear or wound the bark.

In mid-winter, when the nuts are ripe, they are cut off with their twigs, by a sharp cres-centric knife, attached to the extremity of a long pole, which is held in the hands, and pushed upwards against the twigs, removing at the same time such as are fruitless. The capsules are gently pounded in a mortar to loosen the seeds from their shells, from which they are separated by sifting. To facilitate the separation of the white sebaceous matter enveloping the seeds, they are strained in tubs, having convex, open wicket bottoms placed over cauldrons of boiling water. When thoroughly heated they are reduced to a mash in the mortar, and thence transferred to bamboo sieves, kept at an uniform temperature over hot ashes. A single operation does not suffice to deprive them of all their tallow, and the steaming and sifting is therefore repeated. The article thus procured becomes a solid mass on falling through the sieve, and to purify it, it is melted and formed into cakes for the press. These receive their form from bamboo hoops a foot in diameter and three inches deep, which are laid on the ground over a little straw. On being filled with the hot liquid the ends of the straw beneath are drawn up and spread over the top, and when of sufficient consistence are placed with their rings in the press. This apparatus, which is of the rudest description, and constructed of two large beams placed horizontally so as to form a trough, is capable of containing about fifty of the rings with their sebaceous cakes; at one end it is closed, and at the other adapted for receiving wedges, which are successively driven into it by ponderous sledge hammers, wielded by athletic men. The tallow oozes in a melted state into a receptacle below where it cools; it is again melted and poured into tubs, smeared with mud to prevent its adhering. It is now marketable, in masses about 80 pounds each—hard, brittle, white, opake, without taste, and without the odor of animal tallow; under high pressure it scarcely stains bibulous paper; melts at 104° Fahrenheit. It may be regarded as nearly pure stearine, the slight difference is doubtless owing to the admixture of oil expressed from the seed in the process just described. The seeds

yield about eight per cent. of this vegetable stearine, which sells for about five cents per pound.

The process for pressing the oil, which is carried on at the same time, remains to be noticed; it is contained in the *kernel* of the nut, the sebaceous matter which lies *between* the *shell* and *husk* having been separated in the manner described. The kernel and the husk covering it are ground between two stones, which are heated to prevent clogging from the sebaceous matter still adhering. The mass is then placed in a winnowing machine, precisely like those in common use in other countries. The chaff being separated exposes the white oleaginous kernels, which after being steamed are placed in a mill to be mashed. This machine is formed of a circular stone groove, twelve feet in diameter, three inches deep and about as many wide, into which a thick solid stone wheel, eight feet in diameter, tapering at the edge, is made to revolve perpendicularly by an ox harnessed to the outer end of its axle, the inner turning on a pivot in the centre of the machine. Under this ponderous weight the seeds are reduced to a mealy state; they are then steamed in the tubs, formed into cakes, and pressed by wedges in the manner above described, the process of mashing, steaming, and pressing being repeated with the kernels likewise. The kernels yield above thirty per cent of oil, and it sells for a little more than three cents per pound. It is called *Tsing-yu*, and answers well for lamps, though inferior for this purpose to some other vegetable oils in use. It is also employed for various purposes in the arts, and has a place in the Chinese Pharmacopœia, because of its quality of changing grey hair black, and other imaginary virtues. The husk which envelops the kernel, and the shell which encloses them with their sebaceous covering, are used to feed the furnaces, scarcely any other fuel being needed for this purpose. The residuary tallow cakes are also employed for fuel, as a small quantity of it remains ignited a whole day. It is in great demand for chafing dishes in the cold weather. And finally, the cakes which remain after the oil has been pressed out are much valued as a manure, particularly for tobacco fields, the soil of which is rapidly impoverished by the Virginia weed. Artificial illumination is generally procured in China by vegetable oils, but candles are also employed by those who can afford it, and for lanterns. In religious ceremonies no other material is used. As no one ventures out after dark without a lantern, and as the gods cannot be acceptably worshipped without candles, the quantity consumed is very great. With an unimportant exception, the candles are also made of what I beg to designate as *vegetable stearine*. When the candles, which are made by dipping, are of the required diameter, they receive a final dip into a mixture of the same material and *insect-wax*, by which their consistency is preserved in the hottest weather. They are generally colored red, which is done by throwing a minute quan-

tity of Alkanet root (*Anchusa tinctoria*), brought from Shang-tung, into the mixture, which forms the coating of the candle; Verdigris is sometimes employed to dye them green. The wicks are made of rush, coiled round a stem of coarse grass, the lower part of which is slit to receive the *pin* of the candlestick, which is more economical than if put into a socket. Tested in the mode recommended by Count Rumford, these candles compare favorably with those made from spermaceti, but not when the clumsy wick of the Chinese is used. They cost about eight cents per pound.

Prior to the thirteenth century, beeswax was employed as a coating for candles; but about that period the white *insect-wax* was discovered, since which time that article has been wholly superseded by the more costly but incomparably superior product of this insect. It has been described by the Abbé Grassier, Sir George Staunton, and others; but these accounts differ so widely among themselves, as well as from that given by native authors, as to render further inquiry desirable.

From the description given by Grassier, entomologists have supposed the insect which yields the *Pe-la*, or white wax, to be a species of Coccus. Staunton on the contrary describes it as a species of Cicada (*Flata limbata*). As described by Chinese writers, however, it is evidently an *apterous* insect, hence the inference, either that there are two distinct species that produce white wax, or that the insect Staunton saw was falsely represented as the elaborator of this beautiful material. This like many other interesting questions in the natural history of this portion of the globe must remain unsolved, until restrictions on foreign intercourse are greatly relaxed, or wholly removed. In the mean time, native writers may be consulted with advantage; and from the chief of these the Pun-tsau and Kiunfangpú, two herbals of high authority, the subjoined account has been principally derived. The animal feeds on an evergreen shrub or tree, *Ligustrum incidum*, which is found throughout central China from the Pacific to Thibet, but the insect chiefly abounds in the province of Sy'Chuen. It is met with also in Yunnan, Hunan, and Hupeh. A small quantity of a superior description, is produced in Kinhwa Chehkiang province. Much attention is paid to the cultivation of this tree; extensive districts of country are covered with it, and it forms an important branch of agricultural industry. In planting, they are arranged like the mulberry in rows about twelve feet apart, and both seeds and cuttings are employed. If the former, they are soaked in water in which unhusked rice has been washed, and their shells pounded off; when propagated by cuttings, branches an inch in diameter are recommended as of the most suitable size. The ground is ploughed semi-annually, and kept perfectly free from weeds. In the third or fourth year they are stocked with the insect. After the wax or insect has been gath-

ered from the young trees, they are cut down, just below the lower branches, about four feet from the ground, and well manured. The branches which sprout the following season are trimmed, and made to grow in nearly a perpendicular direction. The process of cutting the trunk within a short distance of the ground is repeated every four or five years, and as a general rule, they are not stocked until the second year after this operation. Sometimes the husbandman finds a tree which the insects themselves have attained, but the usual practice is to stock them with the nests of the insect, which is effected in spring. These nests are about the size of a "fowl's head," and are removed by cutting off a portion of the branch to which they are attached, leaving an inch each side of the nest. The sticks, with the adhering nests, are soaked in unhusked rice-water for a quarter of an hour, when they may be separated. When the weather is damp or cool, they may be preserved in jars for a week; but if warm, they are to be tied to the branches of the trees, to be stocked without delay, being first folded between leaves. By some, the nests are probed out of their seat in the bark of the tree without removing the branches. At this period they are particularly exposed to the attacks of birds, and require watching. In a few days after being tied to the tree, the nests swell, and innumerable white insects, the size of "*nits*," emerge, and spread themselves on the branches of the tree; but soon with one accord they descend towards the ground, where, if they find any grass, they take up their quarters. To prevent this, the ground beneath is kept quite bare, care being taken also that their implacable enemies, the ants, have no access to the tree.

Finding no congenial resting place below, they reascend and fix themselves to the lower surface of the leaves, where they remain several days, whence they repair to the branches, perforating the bark to feed on the fluid within. From nits they attain the size and appearance of "*pediculus hominis*." Having compared it to this, the most familiar to them of all insects, our authors deem further description superfluous. Early in June they give to the trees the appearance of being covered with hoar frost, being *changed into wax*, soon after this they are scraped off, being previously sprinkled with water. If the gathering be deferred till August they adhere too firmly to be easily removed. Those which are suffered to remain to stock trees the ensuing season secrete a purplish envelop about the month of August, which at first is no larger than a grain of rice; but as incubation proceeds, it expands, and becomes as large as a fowl's head, which is in spring, when the nests are transferred to other trees, one or more to each, according to their size and vigor, in the manner already described.

On being scraped from the trees, the crude material is freed from its impurities, probably the integuments of the insect, by spreading

it on a strainer covering a cylindrical vessel which is placed in a cauldron of boiling water; the wax is received into the former vessel, and on congealing is ready for the market. The Pe-la or white wax in its chemical properties is analogous to purified beeswax, and also spermaceti, but differs from both, being in my opinion an article perfectly *sui generis*. It is purely white, transparent, shining, not unctuous to the touch, inodorous, insipid, crumbles into a dry inadhesive powder between the teeth, with a fibrous texture, resembling fibrous calc-spar; it melts at 100° Fah., is insoluble in water, dissolves in heated essential oils, and is scarcely affected by boiling alcohol, the acids, or alkalies.

The aid of analytical chemistry is needed for the proper elucidation of this most beautiful material. There can be no doubt it would prove altogether superior in the arts to purified beeswax. On extraordinary occasions the Chinese employ it for candles and tapers. It has been supposed to be identical with the white lac of Madras; but as the Indian article has been found useless in the manufacture of candles,* it cannot be the same; it far excels also the vegetable wax (Myrica cerifera) of the United States.

Is this substance a secretion? There are Chinese who regard it as such, some representing it to be the saliva and others the excrement of the insect. European writers take nearly the same view, but the best authorities expressly say that this opinion is incorrect, and that the animal is changed into wax. I am inclined to believe that the insect undergoes what may be styled a ceraceous degeneration, its whole body being permeated by the peculiar produce in the same manner as the Coccus cacti is by *carmine*.

Its cost at Ningpo varies from 22 to 33 cents per pound.

The annual produce of this humble creature in China cannot be far from 400,000 pounds, worth more than $100,000.

Ningpo, August, 1850.

ART. V.—*On the sudden disappearance of the Ice on Lake Champlain, at the breaking up of Winter*; by Rev. ZADOCK THOMPSON, of Burlington, Vermont.

THE vanishing of the ice on Lake Champlain in spring is at times so sudden, as to strike general observers with much surprise. But, for myself, although I have lived thirty years upon its shores, where I have had a full view of its broadest part, and where I have watched its closing in winter and its opening in spring, with no inconsiderable interest, I have not in that time witnessed anything, in relation to the phenomenon above mentioned, which has appeared to me either mysterious or very wonderful. In the last fifty years there have been a few cases (cer-

* Dr. Pearson's Philosophical Transactions, vol. xxi.

tainly not more than three or four), in which the lake has been entirely covered with ice on one day, and entirely clear of ice on the next. One case only of this kind has occurred within the period of my own observations, and that took place about twenty years since. The ice at that time, though of considerable thickness, had become exceedingly porous and rotten, and for some days had been considered unsafe; but, having been stiffened at its surface by a sharp frost in the night, some persons ventured upon it in the morning, and passed safely over the lake on foot, where the width is six or seven miles; but during the day a storm set in, with a very strong wind, and, on the following morning, the ice had entirely disappeared; there was none to be seen on the lake.

Now an occurrence of this kind is certainly calculated to excite wonder in the mind of the general observer, and make the sudden clearing of the lake a common topic of conversation; but it appears to me that all the mystery about the matter vanishes at once whenever the circumstances are carefully considered. These circumstances I have stated in general terms in Part I, p. 14 of my Nat. and Civil Hist. of Vermont, published in 1842. But experiments and observations made since that time require me to modify some of the statements there presented. It was then supposed that, when the ice commenced forming upon the surface of the lake, the great body of water below was at a temperature of about 39° or 40°. This, according to the researches of Count Rumford, would doubtless be true were the waters cooled down without agitation; but I find it is not true in fact, and from the observations I have made, I am now inclined to the opinion that, in consequence of their violent agitation by the cold winds which prevail in the early part of winter, the whole mass of waters is usually cooled down very nearly to the freezing point before any ice forms at the top, and that, after the waters are protected from the winds by a covering of ice, their temperature is gradually raised by the reception of heat from the earth beneath.

Since the publication of my history of Vermont I have made some experiments for the purpose of ascertaining the temperature of the water of the lake at various depths, after it had been for some time entirely covered with ice. In all these I have found the temperature some degrees above freezing, but not quite so much above as I had previously supposed. As an example, I copy the following record from my meteorological journal for 1844:

"March 27. Temperature of the water of the lake in contact with the ice, 32°; *six* feet below the surface, 32½°; *twelve* feet below, 34½°; and *twenty-five* feet below, being the whole depth of the lake at that place, 35½°." These observations were made nearly one-fourth of a mile from the shore, and after the lake had been covered with ice about eight weeks.

It has long been my intention to ascertain the temperature at the bottom of the deeper parts of our lake when covered with ice,

but I have not hitherto examined where the depth has exceeded 35 feet; I should have attempted it this spring but for the unexpected disappearance of the ice, the last of March.*

A few days after the disappearance of the ice this year, I found the temperature of the water to be 36½°, and, as the lake was at the time much agitated by the wind, this was, doubtless, very nearly the mean temperature of the whole mass of water.

There are three well attested facts connected with this subject, which, taken together, appear to me to afford a full and satisfactory explanation of the phenomenon.

1. The great body of ice is previously always reduced to the *honey-comb* structure, in which condition any considerable agitation of the water causes it to separate into minute divisions.

2. The temperature of the great mass of water is always several degrees above the freezing point, and in a condition to dissolve the minute divisions of ice with great facility when agitated in it.

3. The phenomenon is always attended by a very high wind, producing the agitation required.

In addition to theoretic objections to the opinion that the ice sinks when it disappears suddenly, we, who live on the shores of the lake, think we have ocular proof that it does *not* take place. We see the ice, while yet spreading over the whole surface of the lake, gradually wasting as the spring advances, and becoming less firm, till at length it is so far disintegrated that a stick may be easily thrust through it, while it is still from six to twelve inches thick. This disintegration is often carried so far, before the general icy covering is disturbed, that the ice has little more solidity or tenacity than loose snow saturated with water. In this state of things a strong wind soon produces rents in the ice, the waters, before pent up and quiet, are thrown into violent agitation, and we actually see the slightly cohering masses falling to pieces and dissolving at the surface of the lake; but we never see the ice sinking, nor can I learn that any evidence of this has ever been observed in masses lying at the bottom of the lake.

The objection to this hypothesis—"that so sudden and extensive a conversion of a solid into a fluid, as it supposes, would produce a sudden and violent frost through the neighboring country,"—would, undoubtedly, have weight were the caloric required

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* Although the lake this year began to open, in some places, before the middle of March, it remained mostly covered with ice of considerable thickness and firmness till the 29th of that month, when, in the afternoon, a brisk wind sprang up from the south, which increased to a strong gale during the night, and continued to blow with great violence in the same direction during the 30th and up to noon on the 31st, when it changed to the west and blew a strong gale in that direction through the remainder of the day. Before evening on the 30th, the ice had all vanished from the broader parts of the lake, and on the 1st day of April, the lake and bays, so far as visible from this place, were entirely cleared of ice. This, considering the thickness and firmness of the ice at the time, is one of the most remarkable clearances of the lake we have witnessed for several years.

to liquefy the ice supposed to be derived wholly or principally from the atmosphere. But this I do not believe to be the fact. The process of liquefaction is aided, more or less, according to the temperature, by the warmth of the atmosphere, and, to the same extent, the air is cooled; but the great supply of caloric for the liquefaction of the ice is derived from the waters beneath. This absorption of heat from the waters below has no effect in diminishing the temperature of the air above. By it, the great mass of water may be cooled down a few degrees, still leaving the surface of the lake, in contact with the atmosphere, warmer by some degrees than the previous covering of ice. If we assume, for example, the average depth of Lake Champlain to be fifty feet, and the thickness of the ice to be eight inches, and the temperature of the water below to be 36°, immediately before the sudden disappearance of the ice, (and these do not, probably, differ very much from the usual conditions,) then, since the heat of fluidity in water is 140°, it is easy to calculate that the sudden liquefaction of the ice, by heat derived wholly from the water, would diminish the temperature of the whole mass of water less than two degrees, leaving the surface in contact with the atmosphere more than two degrees warmer than the ice.

There are some other phenomena connected with this lake, which I regard as interesting, but I defer touching upon them to another time.

Burlington, Vermont, April, 1851.

ART. VI.—*On Coral Reefs and Islands;* by JAMES D. DANA.—

Part II.

From the Report on Geology of the Exploring Expedition under Capt. Wilkes, U. S. N.

3. CORAL ISLANDS.

A. Forms and general features of Coral Islands.

A barrier reef, and a lagoon enclosed by it, are the prominent features of a coral island; yet there are a few of small size in which the lagoon is wanting. In the larger islands, the waters within look like the ocean, and are similarly roughened by the wind, though not to the same extent. Standing on the north shore of the Raraka lagoon, (in the Paumotus,) and looking southwest, nothing is descried but blue waters;—far in the distance, to the right or left, a few faint dots are distinguished; and as the eye sweeps around, these gradually enlarge into lines of palms and other verdure, which finally become distinct groves on nearing the observer. At Dean's Island, another of the Paumotus, and at many of the Carolines, the resemblance to the ocean is still more striking. The lagoon is in fact but a fragment of the ocean cut

off by more or less perfect walls of coral reef-rock ; and the reef is here and there surmounted by verdure, forming a series of islets.

In many of the smaller coral islands, the lagoon has lost its ocean character, and become a shallow lake, and the green islets of the margin have coalesced in some instances into a continuous line of foliage. Traces may perhaps be still detected of the passage or passages over which the sea once communicated with the internal waters, though mostly concealed by the trees and shrubbery which have spread around and completed the belt of verdure. The coral island is now in its most finished state : the lake rests quietly in its bed of palms, hardly ruffled by the storms that madden the surrounding ocean.

From the islands with small lagoons, there is every variety in gradation down to those in which there is no trace of a lagoon. These simple banks of coral are the smallest of coral islands.

These remarks, in connection with the general view given on a preceding page, will prepare the reader to appreciate the following descriptions of various coral islands, illustrating their forms, actual size, and condition.

A single group of islands, the Tarawan or Kingsmills, (see Plate,) affords good examples of the principal varieties. The irregularity of shape and size is at once apparent to the eye. In the southernmost, *Taputeouea*, the form is very narrow, the length being thirty-three miles, with the width of the southern portion scarcely exceeding six miles, and that of the northern more than one-half less. The emerged land is confined to one side, and consists of a series of islets upon the eastern line of coral reef. The western side is for the most part some feet under water, and there is hardly a proper lagoon. Sailing by the island, to windward, the patches of verdure thus strung together seem to rise out of a long white line of breakers, the sea surging violently against the unseen coral reef upon which they rest.

Namouti, the next island north, is about twenty miles long by eight broad. The rim of land, though in fewer islets, is similar to that of Taputeouea in being confind to the reef fronting northeast. The reef of the opposite side, though bare of vegetation, stands near low tide level, and the whole encloses a large lagoon.

Nanouki and *Apamama*, though smaller than Namouti, have the same general character. Nanouki is triangular in shape, and has an islet on the western point or cape, which is quite prominent. Apamama differs from either of the preceding in having two narrow ship entrances to the lagoon, one through the northwestern reef, and another through the southwestern.

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* The plate is a reduced copy of the chart of these islands, as surveyed by the Exploring Expedition.

Kuria is a remarkable double island, without a proper lagoon. It consists of two neighboring groves, each about a square mile in extent, on adjacent patches of reef.

Maiana is quite regularly quadrangular, with an uninterrupted range of land on two of the four sides, and an exposed reef constituting the other two.

Turawa consists of two sides of a triangle. The western reef is wanting, and the sea and lagoon have unbroken communication. In place of it, there are two to ten fathoms water, and a bottom of coral sand. Small vessels may sail in almost anywhere on this side to a good anchorage, and there is a passage for ships of the largest size. The depth within is greater than on the bar, and these inner waters obviously correspond to the lagoon of other islands.

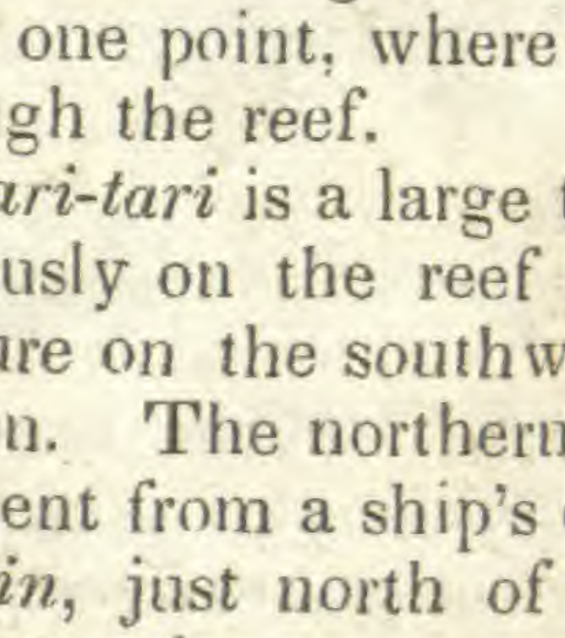
Apia has much resemblance to Apamama in its forest border and lagoon. Moreover, there is a ship-entrance through the southwestern reef.

Maraki is one of the prettiest coral islands of the Pacific. The line of vegetation is unbroken; and from the mast-head it lies like a garland thrown upon the waters. The unpracticed eye scarcely perceives, in such a view, the variation from a circular form, however great it may be. The grove is partially interrupted at one point, where there are indications of a former passage through the reef.

Tari-tari is a large triangular atoll. It is wooded almost continuously on the reef facing southeast, and has a few spots of verdure on the southwest, with three entrances to the extensive lagoon. The northern side is a naked reef throughout, scarcely apparent from a ship's deck, except by the long line of breakers. *Makin*, just north of Tari-tari, is a mere patch of coral reef without a lagoon.

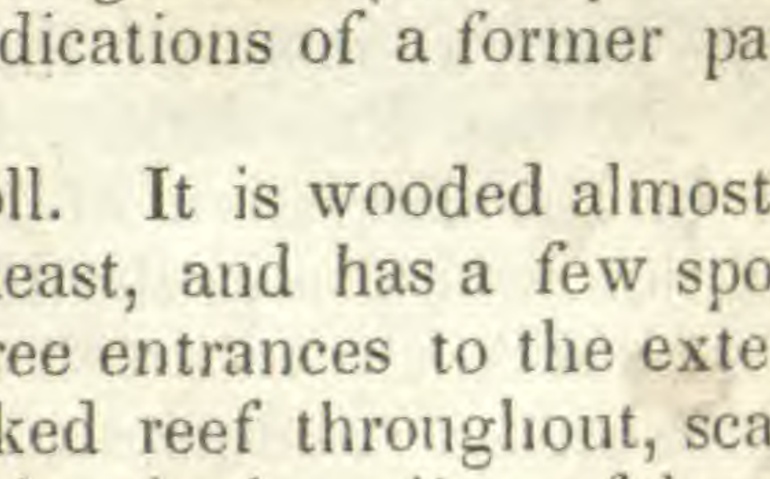
We add a few more descriptions of Pacific islands, with figures reduced from the maps of the Expedition to a scale of four tenths of an inch to a mile.

1.



TAIARA.

2.



HENUAKE OF HONDEN.

Taiara and *Henuake*, (figs. 1 and 2,) are two small belts of foliage, somewhat similar to Maraki. Henuake possessed an additional charm in being tenanted only by birds; and they were so tame that we took them from the trees as if they had been their flowers.

Swain's and *Jarvis* Islands, (figs. 3 and 4,) are of still smaller size, and have no lagoon. The former is densely covered with foliage, while the surface of the latter is sandy. Swain's Island is a little depressed about the centre, a fact indicating that there was formerly a lagoon.

3.

SWAIN'S ISLAND.

4.

JARVIS ISLAND.

Fakaafo, or Bowditch, (fig. 5,) 200 miles north of Samoa, is the type of a large part of coral islands. The bank of reef has only here and there emerged from the waves and become verdant; in other portions the reef is of the usual height,—that is, near low tide level,—excepting a few spots elevated a little by the accumulation of sand.

5.

FAKAAFO.

The Paumotu Archipelago, the crowded cluster of coral islands just northeast of Tahiti, is a most instructive study for the reader; and a map of these islands by the Expedition, inserted in the Narrative of the Expedition, and also in the Hydrographical Atlas, will well repay close study. Sailing among these islands—over eighty in number, only four of which are over twelve feet high exclusive of the vegetation,—two or three are almost constantly in sight from the mast-head.

The small amount of habitable land on these reef-islands is one of their most peculiar features. Nearly the whole surface is water; and the land around the lagoon is but a narrow rim, the greater part of which is usually under water at high tide. This fact will be rendered more apparent from the following table, containing a statement of the sizes and areas of several islands, with the amount of habitable land. The measures are given in geographical miles.

	Length.	Greatest breadth.	Area in square miles.	Habitable parts in square miles.
Carlshoff, Paumotus,	27	13	200	10
Wolchonsky, "	15	3	40	3
Raraka, "	15	10	90	8
Manhii, "	14	6½	50	9
Nairsa or Deans, "	50	19	1000	16
Fakaafo, Union Group,	7½	4½	20	2½
Clarence, "	8½	5½	27	2
Toputeouea, Kingsmills,	33	6	60	6
Tarawa, "	20	10	130	8
Namouti, "	22	9	125	7
Tari-tari, "	18	11	110	4

The ten islands here enumerated have an aggregate area of 1952 square miles, while the amount of actual dry habitable land is but seventy-six miles, or less than one twenty-fourth. In the Caroline Archipelago the proportion of land is still smaller. Menchikoff atoll covers an area of 500 square miles, and includes hardly six square miles of wooded land. In the Marshall Islands the dry land is not over one-hundredth of the whole surface; while in the Pescadores the proportion of land to the whole area is about as 1 to 200.

The distribution of the land upon the reef is obvious from the sketches already given. It was long since remarked that the windward side was in general the highest. It is also apparent that there are not only great irregularities of form, but the reef may at times be wholly wanting or deeply submerged on one side.

In many islands there is a ship entrance, sometimes six or eight fathoms deep, through the reef to the lagoons, where good anchorage may be had; but the larger part have only shallow passages, or none at all. In the Paumotus, out of the twenty-eight visited by the Expedition, not one half were found to have navigable entrances. In the Carolines, where the islands are large and not so much wooded, entrances are of more common occurrence. About half of the Kingsmill Islands afford a good entrance and safe anchorage. Through these openings in the reefs, there is usually a rapid outward current, especially during the ebbing tide. At Depeyster Island, it was found to run at the rate of two and a half miles an hour. It was as rapid at Raraka, in the Paumotus, and as Capt. Wilkes remarks, it was difficult to pull a boat against it, into the lagoon.

Soundings about Coral Islands.—The water around coral islands deepens as rapidly and in much the same way as off the reefs about high islands. The atoll usually seems to stand as if stilted up in a fathomless sea. The soundings of the Expedition afford some interesting results.

Seven miles east of Clermont Tonnerre, the lead ran out to 1145 fathoms (6870 feet), without reaching bottom. Within three quarters of a mile of the southern point of this island, the lead, at another throw, after running out for a while, brought up an instant at 350 fathoms, and then dropped off again and descended to 600 fathoms without reaching bottom. On the lead, which appeared bruised, a small piece of white coral was found, and another of red; but no evidence of *living* zoophytes. On the east side of the island, three hundred feet from the reef, a bottom of coral sand was found in 90 fathoms; at one hundred and eighty feet, the same kind of bottom in 85 fathoms; at one hundred and thirty feet, a coral bottom in 7 fathoms;—and from this it decreased irregularly to the edge of the shore reef.

Off the southeast side of Ahii (another of the Paumotus), about a cable's length from the shore, the lead after descending 150 fathoms, struck a ledge of rock, and then fell off and finally brought up at a depth of 300 fathoms.

Two miles east of Serle's Island, no bottom was found at 600 fathoms.

A mile and a half south of the larger Disappointment Island, there was no bottom at 550 fathoms.

Near the eastern end of Metia, no bottom was found with a line of 150 fathoms; and a mile distant, no bottom was reached at 600 fathoms.* In general, for one to five hundred yards from the margin of the shore reef, the water slowly deepens, and then there is an abrupt descent, at an angle of 40 or 50 degrees. The results of earlier voyagers, among whom Beechey stands pre-eminent, correspond with this statement. At considerable depths, as would appear from the above facts, the sides of the coral structure may be vertical or even may overhang the bottom below.

There are examples also of less abrupt slopes. Northwest of the Hawaiian Group, Lisiansky, at the island bearing his name, found shallow water for a distance of six or seven miles; the water deepened to ten or eleven fathoms the first mile, fifteen the second, and at the last throw of the lead there were still but twenty-five fathoms.† Christmas Island affords on its western side another example of gradually deepening waters. Yet these shallow waters terminate finally in a rapid declivity of forty or fifty degrees. Off the prominent angles of an atoll, soundings generally continue much beyond the distance elsewhere, as was first observed by Beechey. At Washington Island, mostly abrupt in its shores, there is a bank, according to the surveys of the Expedition, extending from the east point to a distance of half a mile, and another on the west extending to a distance of nearly two

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* Beechey, whose observations on soundings are the fullest hitherto published, states many facts of great interest. At Carysfort Island, he found the depth 60 yards from the surf line, 5 fathoms;—80 yards, 13 fathoms;—120 yards, 18 fathoms;—200 yards, 24 fathoms;—and immediately beyond, no bottom with 35 fathoms. At Henderson's Island, soundings continued out 250 yards, where the depth was 25 fathoms, and then terminated abruptly. Off Whitsunday, 500 feet out there was no bottom at 1500 feet.

Darwin states many facts bearing upon this subject, of which we may cite the following.—At Heawandoo Pholo (one of the Maldives) Lieutenant Powell found 50 or 60 fathoms close to the edge of the reef. One hundred fathoms from the mouth of the lagoon of Diego Garcia, Captain Moresby found no bottom with 150 fathoms. At Egmont Island, 50 fathoms from the reef, soundings were struck in 150 fathoms. At Cardoo Atoll, only 60 yards from the reef, no bottom was obtained with a line of 200 fathoms. Off Keeling Island, 2200 yards from the breakers, Captain Fitzroy found no bottom at 1200 fathoms. Mr. Darwin also states that at a depth between five and six hundred fathoms, the line was partly cut as if it had rubbed against a projecting ledge of rock; and deduces from the fact "the probable existence of submarine cliffs."

† Voyage round the world, in the years 1803–6, in the ship Neva, by N. Lisiansky, Captain in the Russian Navy, 4to, London: pp. 254–257.

miles. At Kuria, one of the Kingsmills, soundings continue for three miles from the north extremity, along a bank stretching off from this point to the north-northwest. Many other instances might be cited, but they are seldom as remarkable; yet nearly all islands, especially if the points are much prominent, afford similar facts. It has been said that the reef to leeward is generally less abrupt than that to windward, but no facts were obtained by the Expedition sufficiently definite or extensive to settle this question. It is probably true, yet the difference if any must be slight.

B. Structure of Coral Islands.

The descriptions of reefs and their islets apply with equal force to coral islands. By transferring here the statements respecting the former, we should have a nearly complete account of the latter. The same causes, with scarcely an exception, are at work:—the growing of coral-zoophytes, the action of the waves, oceanic currents, and the winds. This resemblance will be rendered more apparent by a review of their characters; the description will be found to be a simple recapitulation of a former paragraph.

The reef of the coral atoll, as it lies at the surface still uncovered with vegetation, is a platform of coral rock, usually two to four hundred yards wide, and situated so low as to be swept by the waves at high tide. The outer edge, directly exposed to the surf, is generally broken into channels and jagged indentations, along which the waters of the resurging wave drive with great force. Though in the midst of the breakers, the edge stands a few inches, and sometimes a foot, above other parts of the platform; the incrusting *Nullipores* cover it with varied tints, and afford protection from the abrading action of the waves. There are usually three to five fathoms water near the margin; and below, over the bottom which gradually deepens outward, beds of corals are growing profusely among lifeless patches of coral sand and fragments. Often the dead areas much exceed those flourishing with zoophytes, and not unfrequently the clusters are scattered like tufts of vegetation in a sandy plain. The growing corals extend up the sloping edge of the reef, nearly to low tide level. For ten to twenty yards from the margin, the reef is usually very cavernous or pierced with holes or sinuous recesses, a hiding-place for various crabs, or a retreat for the echini, asterias, the sea-anemones, and many a pretty *mollusc*; and over this portion, the gigantic Chama or Tridacna is generally found lying more than half buried in the solid rock, with barely room to gape a little its ponderous shell, and expose to the waters a gorgeously colored mantle. Farther in are occasional pools and basins, alive with all that lives in these strange coral seas.

The reef-rock, wherever broken, shows a detritus origin. Parts are of compact homogeneous texture, a solid white limestone, without a piece of coral distinguishable, and rarely an imbedded shell. But generally the rock is a breccia or conglomerate, made up of corals cemented into a compact mass, and the fragments of which it consists are sometimes many cubic feet in size.

SECTION OF A CORAL ISLAND REEF.

It is apparent that we are describing a second time an *outer* reef. Without dwelling farther upon its characters, we may pass to the features of the reef when raised above the waters and covered with vegetation.

Sections of coral islands and their lagoons have been given by Captain Beechey and Mr. Darwin. We add another, by way of illustration, although little may be presented that is novel after the excellent descriptions of these authors. Sketches of several of these islands, showing the general relation of the rim of land to the reef and the lagoon within, are given in the Plate of the Kingsmill Group. The following sketch represents a section of the rim of land from the sea on one side, (the left,) to the lagoon on the other. In the view, the part *m a*, represents the shallow sea bordering an island, and abruptly deepening one to six hundred feet from the line of breakers. In these shallow waters are the growing corals; yet, as before stated, a large part is barren sand or coral rock.

From *a* to *b* is the shore platform of reef-rock, nearly at low tide level, with the margin (*a*) slightly elevated, and much incrusted at the top with Nullipores. From the platform there is a rise by a steep beach (*b c*,) of six or eight feet, to the wooded part of the coral belt represented between *c* and *d*. From *d* to *e* there is a gently sloping beach bordering the lagoon. Beyond *e*, the waters of the lagoon at first deepen gradually, and then fall off more or less abruptly.

In the Paumotus, the shore platform, the steep beach, and the more gently sloping shore of the lagoon are almost constant characteristics.

The width of the whole rim of land, when the island gives no evidence of late elevation, varies from three hundred yards to one-third of a mile, excepting certain prominent points, more exposed to the united action of winds and waves and from opposite directions, which occasionally exceed half a mile.*

* Beechey states that the rim is generally three to four hundred yards in width, and never exceeds half a mile.—*Voyage*, Amer. ed., p. 160.

Shore platform and emerged land.—The shore platform is from one to three hundred feet in width, and has the general features of a half-submerged outer reef. Its peculiarities arise solely from the accumulations which have changed the reef into an island. Much of it is commonly bare at low tide, though there are places where it is always covered with a few inches or a foot of water; and the elevated edge, the only part exposed, often seems like an embankment preventing the water from running off. The tides, as they rise, cover it with water throughout, and bear over it coral fragments and sand, comminuted shells and other animal remains, to add them to the beach. The heavier seas transport larger fragments; and at the foot of the beach there is often a deposit of blocks of coral or coral rock, a cubic foot or so in size, which low tide commonly leaves standing in a few inches of water.†

Besides the deep channels cutting into the margin of the reef and giving it a broken outline, there are in some instances long fissures intersecting its surface. On Aratica, (Carlshoff,) and Ahii, (Peacock Island,) they extended along for a fourth to half a mile, generally running nearly parallel with the shore, and at top were from a fourth to half an inch wide. These fissures are not essential features of the reef, and will come up for consideration on a future page of this work.

The *beach* usually slopes at an angle of 35 to 45 degrees, and consists of coral pebbles or sand, with some worn shells, and occasionally the exuviæ of crabs and bones of fishes. Owing to its whiteness, and the contrast it affords to the massy verdure above, it is a remarkable feature in the distant view of these islands, and often seemed like an artificial wall or embankment running parallel with the shores. On Clermont Tonnerre, the first of these islands visited by us, the natives seen from shipboard, standing spear in hand along the top of the beach, were believed by some to be keeping patrol on the ramparts of a kind of fortification. This deception arose from the dazzling whiteness of the coral sand, in consequence of which, the slope of the beach was not distinguished in so distant a view.

The *emerged land* beyond the beach, in its earliest stage when barely raised above the tides, appears like a vast field of ruins. Angular masses of coral rock, varying in dimensions from one to a hundred cubic feet, lie piled together in the utmost confusion; and they are so blackened by exposure, or from incrusting lich-

† On moving these masses, which generally rest on their projecting angles and have an open space beneath, the waters at once become alive with fish, shrimps, and crabs, escaping from their disturbed shelter; and beneath, appear various Actinæ or living flowers, the spiny echini and sluggish biche-la-mar, while swarms of shells having a soldier crab for their tenant walk off with unusual life and stateliness. Moreover, delicate corallines, Ascidiæ and sponges tint with lively shades of red, green, and pink, the under surface of the block of coral which had formed the roof of the little grotto.

ens, as to resemble the clinkers of Mauna Loa; moreover, they ring like metal under the hammer. Such regions may be travelled over by leaping along from block to block, with the risk of falling into the many recesses among the huge masses. On breaking an edge from the black masses, the usual white color of coral is at once apparent. Some of the blocks, measuring five or six feet in each of their dimensions, were found to be portions of individual corals, while others have the usual conglomerate character of the reef-rock.

In the next stage, coral sand has found lodgment among the blocks; and though so scantily supplied as hardly to be detected without close attention, some seeds have taken root, and vines, purslane, and a few shrubs begin to grow, relieving the scene, by their green leaves, of much of its desolate aspect.

Both of these stages are illustrated on the greater part of coral islands.

In the last stage, the island stands six to ten feet out of water. The surface consists of coral sand, more or less discolored by vegetable or animal decomposition. There is but little depth of coral soil, although the land may appear buried in the richest foliage: and scattered among the trees, stand, still uncovered, many of the larger blocks of coral, with their usual rough angular features and blackened surface. The soil is seldom discolored beyond four or five inches, and but little of it to this depth; there is no proper vegetable mould, but a simple mixture of darker particles with the white grains of coral sand. It is often rather a coral gravel, and below a foot or two, it is usually cemented together into a more or less compact coral rock.

One singular feature of the shore platform, occasionally observed, remains to be mentioned. Huge masses of reef-rock are sometimes found upon it, some of which lie loose upon the reef, while others are firmly imbedded in it below, and so cemented to it as to appear to be actually a part of the platform rock. Sketches of some of these masses are here given.

1.

2.

Figure 1 represents a mass on the island of Waterland, (one of the Paumotus,) six feet high, and about five in diameter; it was solid with the reef-rock below, as though a part of it, and about two feet above its base, it had been so nearly worn off by the waters as to have become irregularly top-shape. Figure 2 is

another mass, similarly attached to the reef at base, observed on Kawehe, (Vincennes Island.) It was six feet high above low water level, and seven feet in its longest diameter. Below, it had been worn like the one just described, though to a less extent. Another similar mass was eight feet high. Figure 3 represents a block six feet high and ten feet in its longest diameter, seen on Waterland; it was unattached below, and lay with one end raised on a smaller block. On Aratica, (Carlshoff,) others were observed. One loose mass like the last was eight feet high and fifteen feet in diameter, and contained at least a *thousand cubic feet.* Raraka also afforded examples of these attached and unattached blocks, some standing with their tops six feet above high-water mark.

3.

These masses are similar in character to many met with among the fields of blocks just described, and differ only in having been left on the platform instead of being transported over it. Some of them are near the margin of the reef, while others are quite at its inner limit. The third mass figured above was a solid conglomerate, consisting of large fragments of Astræas and Madrepores, and contained some imbedded shells, among which an Ostræa and a Cypræa were noticed. This is their usual character. The other two were parts of large individual corals, (Porites;) but there was evidence in the direction of the cells that they did not stand as they grew; on the contrary, they had been upthrown, and were afterwards cemented with the material of the rock beneath them, probably at the time this rock itself was consolidated. Below some of the loose masses like figure 3, (as on Aratica,) the platform was at times six inches higher than on either side of the mass, owing to the protection from wear given to the surface beneath it. These blocks are always extremely rough and uneven, like those of the emerging land beyond; and the angular features are partly owing in both cases to solution from rains or from the sea-water that may be dashed over them.

It should be distinctly understood that these masses here described were found isolated, and only at considerable intervals. In no instance were they observed clustered. The loose blocks and those cemented below had the same general character, and must have been placed where they were by the same cause, though it may have been at different periods.

The shore of the lagoon is generally low and gently inclined, yet in the larger islands, in which the waters of the lagoon are much disturbed by the winds, there is usually a beach resembling that on the seaward side, though of less extent. A plat-

form of reef-rock at the same elevation as the shore platform sometimes extends out into the lagoon; but it is more common to find it a little submerged and covered for the most part with growing corals: and in either case, the bank terminates outward in an abrupt descent of a few yards or fathoms, to a lower area of growing corals, or a bottom of sand. Still more commonly, we meet with a sandy bottom gradually deepening from the shores without growing coral. These three varieties of condition are generally found in the same lagoon, characterizing its different parts. The lower area of growing corals slopes outward, and usually ceases where the depth is 10 to 12 fathoms; from this there is another descent to the depth which prevails over the lagoon.

On some small lagoons the shore is a thick plastic mud, either white or like clay, and forms a low flat which is very gently sloping. On Henuake, these mud deposits are quite extensive, and of a white color. At Enderby's Island, another having a shallow lagoon, the mud was so deep and thick that there was some difficulty in reaching the waters of the lagoon; the foot sunk in 8 or 10 inches and was not extricated without some difficulty. The color at this island was a dirty brownish clay. This mud is nothing but comminuted coral, so fine as to be almost impalpable.

The *lagoons* of the smaller islands are usually very shallow; and in some, merely a dry bed remains, indicating the former existence of water. Instances of the latter kind are met with only in islands less than three miles in diameter; and those with shallow lagoons are seldom much larger. These shallow waters, when direct communication with the sea is cut off, become, in some instances, very salt by evaporation, and contain no growing coral, with few signs of life of any kind: and in other cases, they are made too fresh for marine life, through the rains. At Enderby's Island the water was not only extremely saline, but the shores of the lagoon were in some places incrusted with salt. But when there is an open channel, or the tides gain access over a bare reef, corals continue to grow, and a considerable portion of the lagoon may be obstructed by them. At Henuake, the sea is shut out except at high water, and there were consequently but few species of corals, and those of small size. At Ahii (Peacock's Island) there was a small entrance to the lagoon, and though comparatively shallow, corals were growing over a large part of it.

In the larger islands, the lagoons contain but small reefs compared with their whole extent; the greater part is an open sea, with deep waters and a sandy bottom. There are instances, as at the southern Maldives, of a depth of 50 and 60 fathoms. Twenty to thirty-five fathoms is the usual depth in the Paumo-

tus. This was the result of Captain Beechey's investigations; and those of the Expedition, though few, correspond. It is however probable that deeper soundings would be found in the large island of Nairsa (Dean's). In the Tarawan Group, southeast of the Carolines, the depth, where examined by the Expedition, varied from 2 to 35 fathoms. Mr. Darwin found the latter depth at Keeling's Island. Chamisso found 25 to 35 fathoms at the Marshall Islands.

The bottom of these large lagoons is very nearly uniform, varying but little except from the occasional abrupt shallowings produced by growing patches of reef. Soundings bring up sand, pebbles, shells, and coral mud; and the last mentioned material appears to be quite common, even in lagoons of considerable size. It has the same character as above described. The bluish clay-like mud of the harbor of Tongatabu may be classed with these deposits.* It appears, therefore, that the finer coral material of the shores prevails throughout the depths of the lagoon. The growing reefs within the lagoons, are in the condition of the *inner* reefs about high islands. The corals grow but little disturbed by the waves, and the reef-rock often contains them in the position of growth. At Taputeouea (Kingsmills or Tarawan Group), reefs very similar to those of the Feejees occur; they present the same large Astræas 10 to 12 feet in diameter, which once were growing where they stand but are now a part of the solid lifeless rock.

Beach formations of coral sandrock are common on the coral islands, and they present the same features in every respect, as those described. They were observed among the Paumotus, on Raraka, Honden, Kawehe, and other islands. The stratified character is always distinct and the layers slope toward the water at the usual small angle, amounting to 5–7 degrees bordering the lagoon, and 7–8 degrees on the seashore side of the land. They often occupy a breadth of 30 to 50 yards, appearing like a series of outcrops; yet not unfrequently they are mostly concealed by the sands of the beach,† and it is probable that it generally underlies the loose surface material of the land. The rock is a fine or coarse sandrock, or a coral pudding-stone, and consists of beach materials. Occasionally it is quite compact, and resembles common limestone, excepting in its whiter color; but generally its sand origin is very apparent.

The *drift sandrock* was not met with by the writer on any coral islands visited, and probably for the reason that opportuni-

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* Darwin describes this mud as occurring at the Maldives, and at Keeling Island, (op. cit. p. 26;) Kotzebue mentions it as common at the Marshall Atolls, and Lieutenant Nelson observed it at the Bermudas.

† On the northern atolls of the Maldives, the beach sandrock is said to be quarried out in square blocks and used for building.—*Journ. Geog. Soc.*, v, 400.

ties were not favorable for a thorough exploration. It has been stated that the more exposed points towards the trades, especially the northeast and southwest, are commonly a little higher than other parts; and it is altogether probable that some of the sand heaps, there formed, will prove on examination to afford examples of this variety of coral-rock. Such situations are exactly identical with those on Oahu, where they occur on so remarkable a scale. Mr. R. H. Schomburgh states that on the island of Anegada in the West Indies, the drift banks on the windward shores are forty feet in height.*

Although in these descriptions of atolls, we have dwelt on some points more at length than when describing barrier reefs, still it will be observed that the former have no essential peculiarities of structure apart from such as necessarily arise from the absence of high rocky lands. The encircling atoll-reef, corresponds with the outer reefs that enclose high islands; and the green islets with the beach formations, in the two cases, originate in the same manner.

The lagoons, moreover, are similar in character and position to the inner channels within barrier reefs; they receive only coral material from the action of degrading agents, because no other source of detritus but the reefs is at hand. The accumulations going on within them are, therefore, wholly of coral. The reefs within the lagoons, correspond very exactly in mode of growth and other characters to the *inner* reefs under the lee of a barrier. The corals grow but little disturbed by the waves, and the reef-rock thus formed, often contains them in their natural positions.

The preceding descriptions, represent the general character of atolls, but are more especially drawn from the Paumotus. There are some peculiarities in other seas, to which we may briefly allude.

Among the scattered coral islands north of the Samoan Group, the shore platform is seldom as extensive as at the Paumotus. It rarely exceeds fifty yards in width, and is cut up by passages often reaching almost to the beach. It was not unusual for our boats to obtain a landing by watching for a favorable opportunity at the entrance of one of these channels to mount a wave and ride in on its top. In some places the platform is broken into islets. Enderby's Island is one of the number to which this description applies: the beach is eleven or twelve feet high. For the first eight feet, it slopes very regularly at an angle of 30 to 35 degrees, and consists of sand, coarse pebbles, or rounded stones of coral, with some shells; and there is the usual beach conglomerate near the water's edge. After this first slope, it is hori-

* Journal of the Royal Geographical Society, ii, 152. Mr. Schomburgh describes the sandhills as 40 feet in height, and behind the first range, a second and even a third.

zontal for eighty to two hundred feet, and then there is a gradual rise of three to four feet. Over this portion there are large slabs of the beach conglomerate, along with masses from the reef-rock, and some thick plates of a huge foliaceous Madrepora; and these slabs, many of which are six feet square, lie inclining quite regularly against one another, as if they had been taken up and laid there by hand. They incline in the same direction with the slope of the beach. The large Madrepora alluded to has the mode of growth of the Madrepora palmata; and probably the entire zoophyte extended over an area twelve or fifteen feet in diameter. The fragments are three to four inches thick, and thirty square feet in surface.

As a key to the explanation of the peculiarities here observed, it may be remarked that the tides in the Paumotus are two to three feet, and about Enderby's Island five to six feet in height.

Maldives.—Chagos Bank.—The Maldives have been often appealed to in illustration of coral structures. They are particularly described by Mr. Darwin, from information communicated to him by Captain Moresby, and from the charts of this officer and Lieutenant Powell.* The point of special interest in their structure is the occurrence of atolls or rings within the larger atolls. The islets of the lagoon, and those of the encircling reef, are in many instances annular reefs, each with its own little lake. Gems within gems are here clustered together.

The annular islets of the main encircling reef are oblong, and lie with the longest diameter, which is sometimes three miles long, in the line of the reef. Those of the lagoon are generally less than two miles across. The lagoons they contain vary from five fathoms or less to twelve fathoms in depth.

The Maldives are among the largest atoll-reefs known; and they are intersected by many large open channels; and Mr. Darwin observes, that the interior atolls occur only near these channels, where the sea has free access. We may view each large island in the archipelago as a sub-archipelago of itself. Although thus singular in their features, they illustrate no new principles with regard to reef-formations.†

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* Darwin on Coral Reefs, p. 32. See also Journal of the Royal Geographical Society, on the Geography of the Maldives, by J. J. Horsburgh, ii, p. 72; and by Captain W. F. W. Owen, ibid, p. 81; also vol. v, p. 398, on the Northern Atolls of the Maldives, by Captain Moresby.

† Mr. Darwin thus remarks, (Op. cit. pp. 33, 34,)—"I can in fact point out no essential difference between these little ring-formed reefs, (which, however, are larger, and contain deeper lagoons than many true atolls that stand in the open sea,) and the most perfectly characterized atolls, excepting that the ring-formed reefs are based on a shallow foundation instead of the floor of the open sea, and that instead of being scattered irregularly, they are grouped closely together."—"It appears from the charts on a large scale, that the ring-like structure is contingent on the marginal channels or branches being wide, and consequently on the whole interior of the atoll being freely exposed to the waters of the open sea. When the

The *Chagos Bank* lies about ten degrees south of the Maldives, and is ninety miles long and seventy broad. The rim is mostly submerged from five to ten fathoms.

Mr. Darwin confirms the opinion of Captain Moresby, that this bank has the character of a lagoon reef, resembling one of the Maldives; and he states on the evidence of extensive soundings, that, if raised to the surface, it would actually become a coral island, with a lagoon forty fathoms deep. In the words of Capt. Moresby, it is in truth nothing more than a half-drowned atoll.*

Metia and other elevated Coral Islands.—In the Chagos Group we have an example of a *sunken* coral atoll. Metia affords an instance of one that has been *elevated* by some force; and several such are met with in the Pacific. Metia, or Aurora Island, is one of the western Paumotus. It is a small island about four miles by two and a half in width, and two hundred and fifty feet in height; and it consists throughout of coral limestone. As we approached it from the northeast, its high vertical cliffs were supposed to be basaltic, and had much resemblance to the Palisades of the Hudson.† This appearance of a vertical structure was afterwards traced to vertical furrowings by the waters dripping down its front, and the consequent formation of stalagmitic incrustations. Deep caverns were also seen.

The cliff, though vertical in some parts, is roughly sloping in others, and on the west side, the surface of the island gradually declines to the sea.

The rock was found to be a white and solid limestone, seldom presenting any traces of its coral origin. In some few layers there were disseminated corals, looking like imbedded fossils, along with beautiful casts of shells; but for the most part it was as compact as any secondary marble, and as uniform in texture. Occasionally there were disseminated spots of crystallized calc-spar.

The caverns presented us with coarse stalactites, some of which were six feet in diameter; and interesting specimens were obtained containing recent land shells, which had been enclosed while hibernating.‡

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channels are narrow, or few in number, although the lagoon be of great size and depth, (as in Suadiva,) there are no ring-formed reefs; where the channels are somewhat broader, the marginal portions of reef, and especially those close to the larger channels are ring-formed, but the central ones are not so: where they are broadest, almost every reef throughout the atoll is more or less perfectly ring-formed. Although their presence is thus contingent on the openness of the marginal channels, the theory of their formation, as we shall hereafter see, is included in that of the parent atolls, of which they form the separate portions."

* Darwin, op. cit., p. 39.

† For a sketch of this island, see Narrative Exp. Exp., vol. i, p. 338.

‡ It is probable that more extensive caverns would have been found, had there been more than a few hours for the examination of the island. The Rev. Mr. Williams, in his work on Missionary Enterprises in the Pacific, gives very interesting

The surface of the island is singularly rough, owing to erosion by rains. The paths that cross it wind through narrow passages among ragged needles and ridges of rock as high as the head, the peaks and narrow defiles forming a miniature model of the grandest Alpine scenery. There is but little soil, yet the island is covered with trees and shrubbery.

The shores, at the first elevation of the island, must have been worn away to a large extent by the sea; and the cliff and some isolated pinnacles of coral rock still standing on the coast are evidence of the degradation. But at present there is a wide shore platform of coral reef, two hundred or two hundred and fifty feet wide, resembling that of the low coral islands, and having growing coral as usual about its margin and in the shallow depths beyond.

In the face of the cliff there are two horizontal lines, along which cavities or caverns are most frequent, which consequently give an appearance of stratification to the rock, dividing it into three nearly equal layers.

We might continue this account of coral reefs and islands, by particular descriptions of those visited by the Expedition. But the similarity among them is so great, and their peculiarities are already so fully detailed, that this would amount only to a succession of repetitions. And moreover the facts will be found in the geographical report by Captain Wilkes, and are to a great extent well exhibited on the map of the Paumotus and on the other valuable charts of the Expedition. The characters of a few briefly stated will suffice in this place. We commence with the smallest.

Jarvis's Island.—(Fig. 4, page 28.) Lat. 0° 22′ S. Long. 159° 31′ W. Length $1\frac{3}{4}$ miles trending east and west. No lagoon. Shape triangular. A low sandy flat, eighteen or twenty feet high, without trees, and partly covered with small shrubs. A high sloping beach continuous around. Trends east and west. We did not land on this island.

Birnie's.—Lat. 3° 35′ S. Long. 171° 39′ W. Four-fifths of a mile by one-third, trending northwest. No lagoon. A sandy flat about ten feet high, except near the north-northeast extremity,

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descriptions of caverns in the *elevated* coral rock of Atiu, one of the Hervey Group.* In one, he wandered two hours without finding a termination to its windings, passing through chambers with "fretwork ceilings of stalagmite and stalactite columns, which, 'mid the darkness, sparkled brilliantly with the reflected torch-light." This author remarks, "that while the madrepores, the brain, and every other species of coral are full of little cells, these islands, (including those resembling Atiu,) appear to be *solid masses of compact limestone, in which nothing like a cell can be detected.*"

Beechey, in his description of Henderson Island, another of this character, speaks of the rock as *compact, and having the fracture of a secondary limestone.*

* Wateoo of Cook.

where it is about twelve feet. To the south-southwest the submerged reef extends out nearly a mile, over which the sea breaks. Distinguished no vegetation except the low purslane and some trailing plants. Did not land.

Swain's.—(Fig. 3, page 28.) Lat. 11° 10′ S. Long. 170° 52′ W. $1\frac{1}{4}$ miles by $\frac{2}{3}$; shape nearly rectangular; trends east and west. No lagoon, but the centre a little lower than the sides. Surface covered with shrubbery and large trees, among the latter many cocoanuts; the centre more sparsely wooded. Height fifteen to eighteen feet, excepting on the middle of western side, where the surface is covered with loose fragments of coral of small size; there appears to have been a former entrance to the lagoon at this place. Shore reef or platform, one hundred yards in average width, and one hundred and fifty yards at the place where we landed. Beach high, ten to twelve feet. At lower part of beach for a height of two to three feet, the coral reef rock was exposed, indicating an elevation of the island. For three or four feet above this, layers of the beach sandrock were often in view, consisting of coral pebbles firmly cemented, and having the usual dip of seven or eight degrees seaward; in many places it was concealed by the beach sands and pebbles. There was no growing coral on the platform excepting Nullipores. The outer margin of this platform was very uneven, and much intersected by channels, though less so than at Enderby's Island.* Great numbers of Birgi, (large Crustacea,) were burrowing over the island, some of which were six inches in breadth.

Otuhu, Paumotu Archipelago.—14° 5′ S. 141° 30′ W. $1\frac{1}{2}$ miles by $\frac{2}{3}$, trending north and south. No lagoon. Wooded.

Margaret, Paumotu Archipelago.—20° 42′ S. 143° 4′ W. Diameter one mile, nearly circular. A small shallow lagoon with no entrance. Northeast side alone wooded, and in two patches.

Teku or *Four Crowns*, Paumotu Archipelago.—20° 28′ S. 143° 18′ W. Diameter $1\frac{1}{2}$ miles, nearly circular. A small lagoon with no entrance. Southwestern reef bare; five patches of forest on the other part.

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* The sea was quite heavy when we attempted to land at low tide upon the edge of the shore platform. As we pulled towards the reef, an anchor was dropped, as usual, some distance out, to hold on and save the boat, from being carried by the surges against the rocks. After some heavy seas had passed, a partial lull seemed to favor, and the boat was pulled in. Taking advantage of the favorable moment, I jumped out, and made rapid speed over the reef to escape the breakers which followed. Soon turning about, I was surprised to find the boat just behind me, and the crew in the water alongside trying to steady her and save her from destruction. The man who held to the anchor behind had let go his hold, and the next sea, as it came careering on, had borne the boat over the edge of the reef, and far on its surface. With even greater risk, after our ramble was completed, we succeeded in launching again and reached the open sea. This was one of many similar dangers experienced in these seas.

Washington Island.—Lat. 4° 41′ N. Long. 160° 15′ W. 3 miles by 1¼, trending east and west. It is a dense cocoanut grove with luxuriant shrubbery. No lagoon. The shore platform is rather narrow. A point of submerged reef one and a half miles long stretches out from southwest end. Could not land on account of bad weather.

Enderby's.—3° 8′ S. 171° 16′ W. 2¾ miles by 1 mile nearly, trending N. N. W. and S. S. E.; form trapezoidal or nearly rectangular. Little vegetation on any part, and but few trees. The lagoon very shallow and containing no growing coral; its shores a coral mud, allowing the foot to sink in eight or ten inches, and covered in places with saline incrustations. Shore platform one hundred feet or less in width, and surface inclined outward at a very small angle; covered with three or four feet of water at high tide, and with few corals or shells; beyond this, falls off four to six feet, and then the bottom gradually inclines for one hundred yards or more. The beach very high and regular; rises eight feet, at an inclination of thirty to thirty-five degrees; then horizontal for eighty to two hundred, after which another rise of three or four feet. It consists below of pebbles and fine sand, but above of slabs and blocks of coral rock and the beach sandrock, those of the latter nearly rectangular and flat. This beach sandrock occurs in layers from ten to twenty inches thick along the shore, and is inclined from five to seven degrees seaward. Some portions are very compact, and ring under the hammer, while others enclose fragments of different sizes to a foot or more in diameter. The most common coral of the beach was an Astræa with small cells, (near A. cerium, D.—the specimens were afterwards lost.) There were also other Astræas, a large lamellar Madrepore, (M. cyclopea,) some fragments of which were six feet square and three inches thick; also Meandrinæ, Porites, &c. Large trunks of transported trees lay upon the island, one of which was forty feet long and four in diameter. The shore platform was much intersected by channels.

Captain Hudson obtained soundings half a mile off in two hundred fathoms; the lead struck upon a sandy bottom but was indented by coral.

Honden, or *Henuake*, Paumotu Archipelago.—Size 3½ miles by 2 miles. Oblong, five-sided; trending west-northwest. A small shallow lagoon, communicating with the sea only at high tide, on the west side. There are two other entrances, which are seldom if ever covered with water, and appeared merely as dry beds of coral rock. Height of the island, twelve feet: lowest on the south side. Belt of verdure complete, and consisting of large forest trees, with the Pandanus and other species, but no cocoanuts; its breadth ½ mile, and in some parts ¾. Among the trees, large masses of coral rock often exposed to view, and the

surface in many parts very rough. It seemed surprising at all these islands to find so luxuriant a growth of trees and shrubbery over so rocky a surface. Shores of the lagoon nearly flat. On one side there was a large area of extremely fine coral sand and mud, which extended a long distance into the lagoon. Elsewhere about the centre of the island, the reef-rock was bare, and contained numerous shells of Tridacnæ. A few small Madrepores still growing in the lagoon. Beach on the sea-shore side eight feet high. In lower part of beach, several layers of white limestone, (the beach sandrock,) formed of coral fragments or sand, shells, &c., much of which was very compact. The layers inclined towards the sea at an angle of about five degrees. Shore platform as elsewhere in this archipelago.

The facts above stated are evidence of a slight elevation, not exceeding two or three feet.

Taiara, or *King's*, Paumotu Archipelago.—15° 42′ S.; 144° 46′ W. $2\frac{2}{3}$ miles by $1\frac{3}{4}$, trending northwest. A small lagoon with no entrance. Reef almost continuously wooded around, somewhat broken into patches.

Maraki, Tarawan or Kingsmills Group.—5 miles by 2, and having a lagoon. Trending north. Shape oblong triangular. Belt of forest complete. Appearance of a former entrance to the lagoon on the east side.

Whytuhu, one of the two Disappointment Islands, Paumotu Archipelago.—14° 10′ S., 141° 24′ W. $5\frac{1}{2}$ by 2 miles, trending northwest. The reef fronting northeast almost continuously wooded. On the opposite side, three islets, one of rather large size. Lagoon with no entrance.

Sydney Island.—Lat 4° 20′ S. Long. 171° 15′ W. Trends northeast and southwest. Well wooded nearly all round; but on leeward side the forest in patches, with breaks of bare coral. Lagoon narrow, without entrance. Width of island from sea to lagoon, one hundred to four hundred yards: width greatest at south end. Beach ten feet high. The soil of the island consisted of coral fragments and sand. Shore platform fifty to eighty feet wide; five or six feet water over it at high tide. Cut up very irregularly by channels three to eight or ten feet wide. Observed small corals growing on the bottom outside of the platform. Shores of lagoon shallow for fifty yards, and consisting of coral sand. Beyond this a slope covered with growing corals. The corals rather tender species of Madrepores. In the interior of the lagoon many knolls and large patches of coral.

Duke of York's.—8° 38′ S., 172° 27′ W. Form irregularly oblong, trending northwest. Length $3\frac{3}{4}$ miles; breadth 2 miles. Circuit $9\frac{1}{2}$ miles, and about one half wooded in patches. Southwest reef mostly bare. A lagoon, but without entrance except for canoes at high tide, on leeward side. Island ten feet high.

Shore platform narrow, and intersected by channels. Shores lined by reef-rock, two or three feet out of water, indicating an elevation of the island. This reef-rock consists of various corals firmly cemented. Within the lagoon, knolls of coral, but none near the shore on the leeward side.

Fakaafo or *Bowditch's*.—9° 20′ S., 171° 5′ W. 6¾ miles by 4. Shape nearly triangular. Circuit seventeen miles, about six of which are wooded in several patches, separated by long bare intervals. A large lagoon, but no ship entrance. Height of island, fifteen feet. Width to the lagoon, one hundred to two hundred yards. Soil of the island coral sand, speckled black with results of vegetable decomposition. Shore platform narrow. At outer edge a depth of three fathoms, and from thence gradually deepens, and abounds in fine corals for fifty yards, when it deepens abruptly. Coral reef-rock elevated three or four feet, indicating an elevation of the island. Lagoon shallow, with some growing coral, but none near the shore. Some corals growing on the platform, near its margin, mostly small Madrepores, Astræas, Nullipores. Fragments of pumice were found among the natives, which had floated to the island.

Ahii, or *Peacock's Island*, Paumotu Archipelago.—14° 30′ S., 146° 20′ W. 13 miles by 6, trending N. E. by E. Shape irregularly oblong. A large lagoon, having an entrance for small vessels on the west. Reef wooded throughout nearly its whole circuit. Lagoon shallow, and much obstructed by growing coral, the latter giving the water over it a clear light green color. Platform, or outer coral shelf of the island, about two hundred and fifty feet wide; under water except at the lowest tides. Margin highest, and covered with Nullipore incrustations, which give it a variety of delicate shades of color, mostly reddish, or peach-blossom red, rose, scarlet. For thirty to fifty feet from the margin, very cavernous, and containing many Tridacnæ, lying half imbedded, with the variously tinted mantle expanded when the surface is covered with water. Rock of the platform either a compact white limestone or a solid conglomerate; dead over its surface, excepting a few Madrepore tufts or Astræas near the margin in pools. In this shelf there were long fissures, extending nearly parallel with the shore, a quarter to half an inch wide at top, and continuing sometimes a fourth of a mile or more. These fissures were commonly filled with coral sand. The higher parts of the island either consisting of loose blocks of coral or covered with some soil; the soil mostly of comminuted coral and shells, with dark particles from vegetable decomposition intermingled. On the bottom exterior to the shore platform, observed the same corals growing as occurred in fragments upon the island; but the larger part of the bottom was without coral, or consisted only of sand.

Raraka, Paumotu Archipelago.—16° 10′ S., 145° W. 14 miles by 8, trending east and west. Shape somewhat triangular. North side nearly continuously wooded: south angle and southwest reef bare. A large lagoon with an entrance for small vessels on the north side. A rapid current flows from the entrance, which it was difficult for a boat to pull against. Shore platform, as usual, about a hundred yards wide, with the edge rather higher than the surface back; the platform mostly bare of water at low tide. Several large masses of coral and coral rock, one to four hundred cubic feet, on the platform and upon the higher parts of the island, some of which stood five and six feet above high-water mark; they were cemented to the reef-rock below, and appeared like projecting parts of the reef. Layers of beach sandrock on the lagoon shores, as well as on the seaward side, inclined at an angle of six or seven degrees: characters as already described. Growing coral in the entrance to the lagoon, within two feet of the surface, mostly a species of Millepora, (M. squarrosa.) Interior of the lagoon not examined for want of time. The water looked as blue as the ocean, and was much roughened by the winds.

Kawehe, or *Vincennes Island*, Paumotu Archipelago, 15° 30′ S., 145° 10′ W. 13 miles by 9, trending north-northwest. Shape irregularly oval. Having a large lagoon, and mostly wooded around, least so to leeward. Between the wooded islets, (as on Raraka and elsewhere.) surface consisted of angular masses of coral rock, (among which the Porites prevail,) strewed in great numbers together; and in some parts bearing a few vines and purslane among the blocks, though scarcely any appearance of soil, or even of coral sand. In other parts, not as high, no vegetation, and surface still wet by high tide. A few large masses of coral on the shore platform, either lying loose, or firmly attached below; some of them were six feet cube, and one was raised seven feet above high-water mark. Those that were attached were so firmly cemented to the reef-rock as to seem to be a part of it, and they were partly worn off below by the wash of the sea; the surface was extremely rough, owing to wear by rains. These masses were sometimes single individual corals, and others were conglomerate in character. Shore platform about a hundred yards wide, rather highest at the edge, and much of its surface two to four feet under water at low tide. As elsewhere, this platform is nothing but a compact coral conglomerate or limestone, having no growing coral over it, except in some shallow pools near its outer margin, where also there are numerous holes in which crabs are concealed, with small fish and other animals of the shores. On the lagoon shore, layers of beach sandrock, six or seven in number, dipping at an angle of seven degrees towards the lagoon, and outcropping one from beneath the other. Similar layers on the sea-shore side.

Manhii, *Wilson's* or *Waterlandt*, Paumotu Archipelago, 14° 25′ S., 146° W. 15 miles by 6, trending E. N. E. A large lagoon with a deep entrance on the west side. Shape oblong triangular.

Shore platform as usual; mostly under water at low tide. Large masses of coral here and there, standing on this reef, either cemented to it or loose. One top-shaped mass is figured on p. 34. High water did not reach the part of it which was most worn; and this was evidently owing to the fact that the action of the swell, or waves, is greatest above the actual level of the tide at the time. This mass was not of fragmentary composition; it was apparently the remains of a single individual Porites. Another loose mass was five and a half feet high, and averaged ten feet across, (fig. 3, p. 35.) It consisted of large masses of Astræas, Madrepores, and Porites cemented together, and contained imbedded shells, an Astræa, Cypræa, &c. The reef-rock is either a compact limestone showing no traces of its composite origin, or a conglomerate. Beach, regular as usual, 6 to 10 feet high, consisting of coral sand, and fragments of worn shells, with occasional exuviæ of crabs, remains of Echini, fish, &c. The entrance to the lagoon is deep and narrow, with vertical sides.

Aratica or *Carlshoff*, Paumotu Archipelago, 15° 30′ S., 145° 30′ W. 17 miles by 10, trending N. E. Large lagoon, with a good entrance for vessels. The reef fronting south, bare for nine miles: on northwest side, mostly very low, with only here and there a clump of trees; occasionally a line of wooded land for a quarter of a mile on the east side; more continuously wooded on the north. The bare parts, mostly covered with blocks of coral, 1 to 30 cubic feet, and larger, tumbled together, as on the preceding. Some blocks of coral on the shore platform very large; one 8 feet high and 15 in diameter, containing at least 1000 cubic feet; it lay on the reef and was not connected with it; below it, the platform was 6 inches higher than the surface either side, owing to the action of the sea. These blocks are in all instances rough angular, and appear as if they had been thrown up by the sea, and left exposed to wear from the rains and spray.

Nairsa or *Dean's*, Paumotu Archipelago, 15° S., 148° W. 44 miles by 17, trending W. N. W. Northern shore mostly wooded; southern with only an occasional islet, connected by long lines of bare reef. In these intervals, the reef stood eight feet or so out of water, and was worn into a range of columns, or excavated with caverns, so as to look very much broken, though quite regularly even in the level of the top line.

We might continue these descriptions; but the above, with the details before given, will convey a general idea of the whole.

C. The Completed Coral Island.

The coral island in its best condition is but a miserable residence for man. There is poetry in every feature: but the natives find this a poor substitute for the breadfruit and yams of more favored lands. The cocoanut and Pandanus are, in general, the only products of the vegetable kingdom afforded for their sustenance, and fish and crabs from the reefs their only animal food. Scanty too is the supply; and infanticide is resorted to in self-defence, where but a few years would otherwise overstock the half-a-dozen square miles of which their little world consists.

Yet there are more comforts than might be expected on a land of so limited extent,—without rivers, without hills, in the midst of salt water, with the most elevated point but ten feet above high tide, and no part more than 300 yards from the ocean. Though the soil is light and the surface often strewed with blocks of coral, there is a dense covering of vegetation to shade the native villages from a tropical sun. The cocoanut, the tree of a thousand uses, grows luxuriantly on the coral-made land, after it has emerged from the ocean; and the scanty dresses of the natives, their drinking vessels and other utensils, mats, cordage, fishing-lines, and oil, besides food, drink, and building material, are all supplied from it. The Pandanus or screw-pine flourishes well, and is exactly fitted for such regions: as it enlarges and spreads its branches, one prop after another grows out from the trunk and plants itself in the ground; and by this means its base is widened and the growing tree supported. The fruit, a large ovoidal mass made up of oblong dry seed, diverging from a centre, each near two cubic inches in size, affords a sweetish husky article of food, which, though little better than prepared corn stalks, admits of being stored away for use when other things fail. The extensive reefs, abound in fish which are easily captured, and the natives, with wooden hooks, often bring in larger kinds from the deep waters. From such resources a population of 10,000 persons is supported on the single island of Taputeouea, whose whole habitable area does not exceed six square miles.*

Water is to be found commonly in sufficient quantities for the use of the natives, although the land is so low and flat. They dig wells five to ten feet deep in any part of the dry islets, and generally obtain a constant supply. These wells are sometimes fenced around with special care; and the houses of the villagers, as at Fakaafo, are often clustered about them. On Aratica (Carls-

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* There are a few islands better supplied with vegetable food, though the above statements are literally true of a large majority.

hoff) there is a watering place 50 feet in diameter, from which our vessels in a few hours obtained 390 gallons. The Tarawan Islands are generally provided with a supply sufficient for bathing, and each native takes his morning bath in fresh water, which is esteemed by them a great luxury. On Taritari, as Mr. Hale was informed by a Scotch sailor taken from the island, by the name of Gray, there is a long trench or canal, described by him as several miles long, and two feet deep. They have *taro* plantations, which require a large supply of water, besides some bread-fruit. These islands have been elevated a little, but are not over fifteen feet above the sea.*

The only source of this water, is the rains, which, percolating through the loose surface, settle upon the hardened coral rock that forms the basis of the island. As the soil is white or nearly so, it receives heat but slowly, and there is consequently but little evaporation of the water that is once absorbed.

These islands moreover enclose ports of great extent, many admitting even the largest class of vessels: and the same lagoons are the pearl fisheries of the Pacific.

An occasional log drifts to their shores, and at some of the more isolated atolls, where the natives are ignorant of any land but the spot they inhabit, they are deemed direct gifts from a propitiated deity. These drift-logs were noticed by Kotzebue, at the Marshall Islands, and he remarked also that they often brought stones in their roots. Similar facts were observed by us at the Tarawan Group, and also at Enderby's Island and elsewhere.

The stones at the Tarawan Islands, as far as we could learn, are generally basaltic, and they are highly valued for whetstones, pestles, and hatchets. The logs are claimed by the chiefs for canoes. Some of the logs, like those at Enderby's Island, were forty feet or more long.

Fragments of pumice and resin are transported by the waves to the Tarawan Islands. We were informed that the pumice was gathered from the shores by the women, and pounded up to fertilize the soil of their taro patches; and it is so common that one woman will pick up a peck in a day. Pumice was also met

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* The Scotchman (Gray) from whom this information was obtained, added that ten ships of the line might water there, though the place was not reached without some difficulty. There were fish in the pond which had been put in while young. The bottom was adhesive like clay. He spoke of the taro as growing to a very large size, and as being in great abundance; it was planted along each side of the pond.

Kotzebue observes, that "in the inner part of Otdia [one of the Marshall Islands] there is a lake of sweet water; and in Tabual, of the group Aur, a marshy ground exists. There is no want of fresh water in the larger islands; it rises in abundance in the pits dug for the purpose."—*Voyage*, London, 1821, iii, 145.

with at Fakaafo. Volcanic ashes are sometimes distributed over these islands, through the atmosphere; and in this manner the soil of the Tonga Islands is improved, and in some places it has received a reddish color.

The officers of the Vincennes observed several large masses of compact and cellular basalt on Rose Island, a few degrees east of Samoa: they were lying two hundred yards inside of the line of breakers. The island is uninhabited, and the origin of the stones is doubtful; they may have been brought there by roots of trees, or perhaps by some canoe.

Notwithstanding the great number of coral islands in the Paumotu Archipelago, the botanist finds there, as Dr. Pickering informs me, only twenty-eight or twenty-nine native species of plants. The following are the most common of them:—

Portulacca, two species.	Pemphis acidula.
Scævola Konigii.	Guettarda speciosa.
Pisonia? one species.	Triumphetta procumbens.
Tournefortia sericea.	Suriana maritima?
Pandanus odoratissimus.	Convolvulus, one species.
Lepidium, one species.	Urtica, one or two species.
Euphorbia, one species.	Asplenium nidus.
Morinda citrifolia.	Achyranthus, one species.
Boerhavia, two species.	A species of grass.
Cassytha, one species.	One or two rubiaceous shrubs.
Heliotropium prostratum.	Polypodium.

On Rose Island Dr. Pickering found only the *Pisonia* and a *Portulacca*. The *Triumphetta procumbens*, a creeping plant, takes root like the Portulacca, in the most barren sands, and is very common. The *Tournefortia* and *Scævola* are also among the earliest species. The *Pisonia*, a tree of handsome foliage, the *Pandanus* or Screw-pine, and the *Cocoanut*, (always an introduced species,) constitute the larger part of the forests. In the Marshall Group, where the vegetation is more varied, Chamisso observed fifty-two native plants, and in a few instances the Banana, Taro, and Breadfruit.

The language of the natives indicates their poverty, as well as the limited productions and unvarying features of the land. All words like those for mountain, hill, river, and many of the implements of their ancestors, as well as the trees and other vegetation of the land from which they are derived, are lost to them; and as words are but signs for ideas, they have fallen off in general intelligence. It would be an interesting inquiry for the philosopher, to what extent a race of men placed in such circumstances are capable of mental improvement. Perhaps the query might be best answered by another, How many of the various arts of civilized life could exist in a land, where shells are the

only cutting instruments,—the plants in all but twenty-nine in number,—but a single mineral,—quadrupeds none, with the exception of foreign mice,—fresh water barely enough for household purposes,—no streams, nor mountains, nor hills? How much of the poetry or literature of Europe would be intelligible to persons whose ideas had expanded only to the limits of a coral island;—who had never conceived of a surface of land above half a mile in breadth,—of a slope higher than a beach,—of a change of seasons beyond a variation in the prevalence of rains? What elevation in morals should be expected upon a contracted islet, so readily over-peopled that threatened starvation drives to infanticide, and tends to cultivate the extremest selfishness? Assuredly there is not a more unfavorable spot for moral or intellectual development in the wide world than the coral island, with all its beauty of grove and lake.

These islands are exposed to earthquakes and storms like the continents, and occasionally a devastating wave sweeps across the land. During the heavier gales, the natives sometimes secure their houses by tying them to the cocoanut trees, or to a stake planted for the purpose. A height of ten or twelve feet, the elevation of their land, is easily overtopped by the more violent seas; and great damage is sometimes experienced. The still more extensive earthquake-waves, such as those which have swept up the coast of Spain, Peru, and the Sandwich Islands, would produce a complete deluge over these islands. We were informed by both Gray and Kirby, that effects of this kind had been experienced at the Tarawan Islands; but the statements were too indefinite to determine whether the results should be attributed to storms or to this more violent cause.

The preceding pages have been occupied with a simple description of the actual condition, structure, and appearances of reefs and reef islands. From this review of their existing features, we may pass on to the consideration of those agencies by which these features were produced, tracing out the steps in the progress of such formations, and the influence of various causes on their forms and distribution. We may commence with a brief account of the living zoophyte, its habits and its mode of growth,—as some knowledge on these points is essential to the correct appreciation of the discussion before us. This branch of the subject has been treated of at length in another volume, to which reference may be made for fuller details.*

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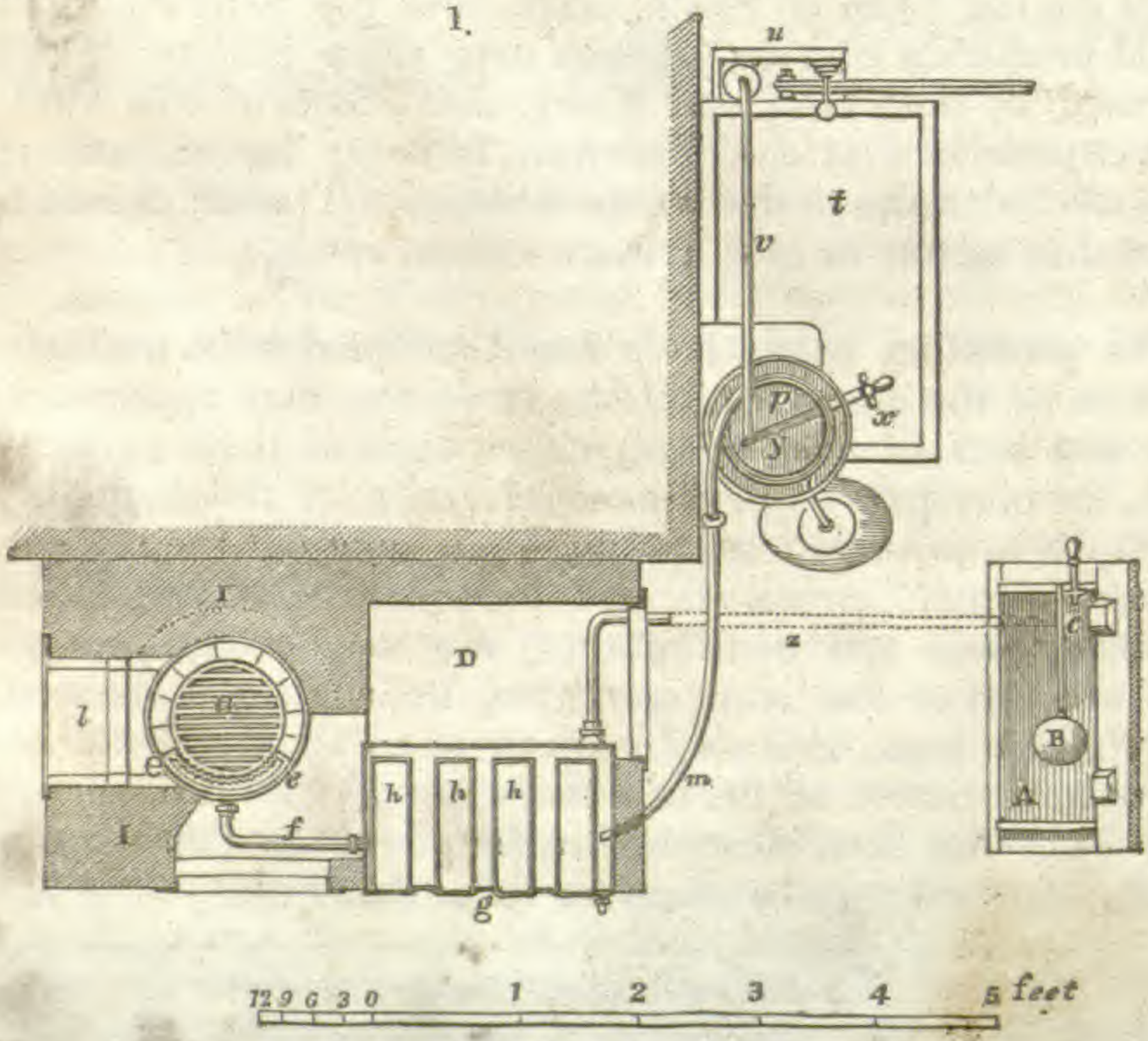
* Report on Zoophytes, by the author.

ART. VII.—*A description of a new Sand-Bath with Water-Bath and Distilling Apparatus attached, erected in the Yale Analytical Laboratory;* by Prof. JOHN P. NORTON.

THIS Sand-Bath was constructed and brought into active employment during the last term in Yale College. Its operation, with that of all its connected parts, has proved so entirely satisfactory, that it has been thought worthy of a notice in this place. There is nothing particularly novel in any one feature, but the combination of conveniences is such as I have never seen equalled, even in the best European laboratories.

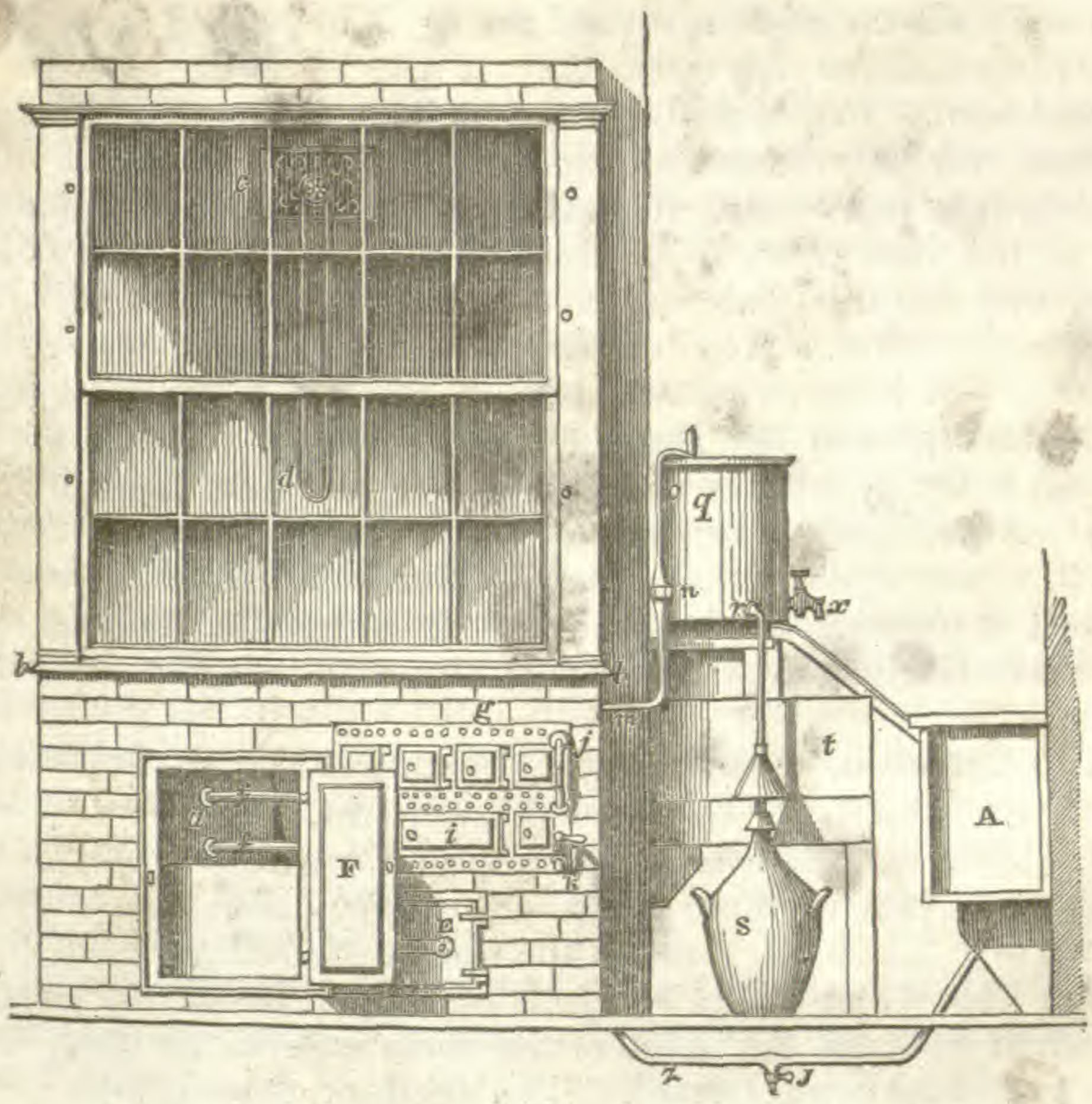
The idea of uniting with the advantages of the sand-bath, those of the water-bath and distilling apparatus, and of accomplishing the working of the whole by means of a single fire, is one that I had before entertained. I long hesitated to attempt its realization, because no model existed; my success in the experiment has however been so complete, that it seems a favor to the chemists of the country, to give such a description as shall enable those who have occasion to build, to adopt an arrangement which possesses the recommendations of efficiency, compactness, and economy of fuel, while at the same time it may be considered almost self-acting.

1.



The accompanying plans and elevations, in figures 1 to 3, will I think with some short comments, sufficiently explain the construc-

2. FRONT ELEVATION.



3. SIDE ELEVATION.

tion and connection of the several parts. They are all drawn accurately to a scale, so that measurements may be taken. No. 1 is the ground plan. In this plan, *a* is the furnace. The position of this furnace may also be seen at *a* in the front elevation, fig. 2. The sand-bath as represented here and in fig. 3, is similar to one put up in the New York Free Academy by Prof. Wolcott Gibbs; from that one this and several others have been copied. The original however, and all of the other copies were simply sand baths. The lower windows slide up, weights being included in the corner pillars; the heat of the fire passes through the bed plate *b b*, fig. 2, heating the sand which lies upon its upper surface. All noxious fumes are conveyed away by the ventilator *c*, fig. 2, which opens into a chimney flue and may be closed or opened at pleasure by the chain *d*. It is then to this sand bath by Prof. Gibbs, that I have made the additions now to be described.

The furnace *a*, is an iron pot, lined inside with fire brick as usual, except *e e*, fig. 1, where is inserted a water-back of large size. This communicates by the pipe *f*, with the water bath *g*. There are two of these pipes, one above, and one below, as shown at *f f*, in fig 2, through the open door. The front elevation of the water bath, which is of copper in all its parts, is shown at *g*, in fig. 2. Each of the doors seen on the front, opens into a separate compartment. The depth of these compartments is shown by the sections *h h h*, in fig. 1. At *i*, fig. 2, is a larger compartment, for receiving articles of considerable size.

At *j* is a glass tube to show the height of water in the water bath, and at *k*, a cock placed so low that all of the water contained may be drawn off, thus removing any small quantity of sediment which occasionally accumulates. These two parts are seen more clearly at *j* and *k*, in fig. 3.

The furnace is fed through a door at *l*. A moderate fire is sufficient to establish a brisk circulation through the pipes *f f*, and causes the water to boil violently in the water bath, keeping it always fully up to 212° F. The steam formed escapes through the pipe *m*, fig. 1, also shown at *m m*, figs. 2 and 3. At *n*, figs. 2 and 3, is a coupling connecting the copper pipe *m*, with a block tin pipe *o*, figs. 2 and 3, and worm *p*, fig. 1. This worm is contained in the condenser *q*, figs. 2 and 3. The distilled water thus produced, escapes at *r*, figs. 2 and 3, and runs into the receiver *s*, beneath. The condenser stands on a shelf over a sink *t*, figs. 1, 2, and 3, at the farther end of which is a force pump *u*, figs. 1 and 3. A pipe *v*, figs 1 and 3, runs from the top of this pump into the condenser. The pump delivers cold water into the sink in the common way, but by closing the cock at *w*, fig. 3, will throw its stream into the condenser. This water when warm is drawn off at the cock *x*, figs. 1, 2, and 3. The pipe

from this cock seen at *y*, fig. 1, rises to within an inch or two of the top of the condenser, so that the warm water is drawn off first. By this arrangement the very great convenience is obtained of a constant supply of hot water, delivered into the sink for washing.

As the well water at New Haven contains a considerable amount of solid matter, which soon encrusts the interior of vessels in which it is steadily boiled, rain water only is used in the water-bath. The supply is kept up through the pipe *z*, as shown in figs. 1, 2 and 3, running under the floor. Its whole course may be traced by these three figures. It rises into the box A, figs. 1, and 3, in which the water stands on a level with the upper part of the glass guage tube, show at *j* in fig. 3. Upon the surface floats a large hollow copper ball, B, fig. 1. As soon as the formation of steam and its consequent passing off into the condenser commences in the water bath, the surface of course lowers, and a corresponding lowering occurs in the box A. The copper ball, B, sinks with the water, and gradually opens a valve at C, fig. 1. This admits a stream of water from an elevated cistern, which flows in just fast enough to supply that which passes off from the water bath as steam.

This arrangement is only novel in its present application, being I believe quite common in some of our cities for regulating the flow of water into cisterns. It works admirably in the present case, and seldom if ever requires any attention. If the fire is very hot, so much steam is occasionally generated, that it is not condensed with sufficient rapidity; a partial flow of hot water back into the box A, has several times occurred under these circumstances, but has never been sufficient to overflow. This difficulty might be avoided by enlarging the conducting pipe *m*, and the worm *p*, or by reducing the size of the water-back *e*, *e*, fig. 1.

The space D, fig. 1, is a large dry hot oven, where quite a high heat is obtained. This is also shown at D, the door being taken off. In this oven a shelf is placed, perforated with holes for the insertion of funnels, tubes, &c. It is in constant use for drying, and is found to be of very great service in all cases where rapid drying is desirable, and a precise temperature is not required. The small door at E, fig. 2, is another means of access to this oven.

The water-bath is set in the brick work, but may be taken out and reset without disturbing the rest of the apparatus, in fact every part is accessible. The couplings to the pipes *f*, *f*, may be reached through the door F; those to the supply pipe *z*, at G, fig. 3, those to the escape pipe, *m*, by taking out a brick at H, fig. 3. In order to obtain ready access to the interior of the furnace pot *a*, there is a large moveable circular plate immediately above; its circumference is shown by the dotted line at I, I, in fig. 1.

The supply of water from the cistern to the box A, is cut off by a stop-cock at the cistern, and the water may be entirely drawn off from the box, by a small cock at J, under the floor.

It will be perceived that this arrangement is compact and simple. There is no part liable to get out of order, or that once out of order, cannot be easily reached for the purpose of repairs.

By means of one fire, and that not large, we heat the sand-bath sufficiently, maintain a large water bath constantly at 212° F., make from ten to fifteen gallons of perfectly pure water per day, heat a large drying oven, and keep a constant supply of hot water over the sink for washing. Everything takes care of itself excepting the fire, and the occasional pumping of cold water into the condenser. I am unable, after two months of experience, to suggest any important improvement in these arrangements, and feel confident that any one who should put up a similar apparatus would not be disappointed.

Prof. Porter of Brown University is partially copying after this model for his new laboratory in that institution.

I must here express my obligations to Mr. Culver, of the firm of Culver & Cory, New York. His practical skill enabled me to overcome several difficulties which at first appeared quite formidable. Nearly all of the iron and copper work was done in the shop of Messrs. Culver & Cory, and in so substantial and satisfactory a manner, that I can safely recommend them to all who may contemplate putting up anything of the kind I have described. Having the patterns and the experience, they can work cheaper and better than those who have never done any such business. The iron work is all japanned. The glass should be set with a putty made of boiled linseed oil, as that will harden under the heat to which it is exposed; the common putty made with fish oil remains soft, and the glass is constantly liable to get out of place.

Art. VIII.—*On Microscopes and Microscopy.*

Prof. J. D. Dana—*Dear Sir:*—I much regret not being able to communicate to you, before now, some facts on microscopes in answer to the inquiries made. But many circumstances have prevented me, and although this may come at rather a late hour, yet I trust it will prove acceptable since the facts relate to a subject possessing at this time more than ordinary interest.

You are aware that lately I have been somewhat in "the microscopic way," and I think that you will learn most from me, by allowing me to go over that portion of the ground that bears on my personal experience.

Mr. Spencer, the optician, is so well known, and his superior attainments in this department have of late been so often discussed in print, that it is unnecessary for me to mention who he is and what he has been doing. The capabilities of his lenses are well known to our first microscopists, and the occasional articles of Prof. Bailey within the past two years, have shown the opinion of one of our first authorities on this subject. But, with all this, I do not recollect to have seen the result of a comparative trial between Spencer's and the best foreign glasses.* It is to this point that I wish to ask your attention.

Last summer I had the good fortune to obtain from him a set of lenses, which he acknowledged, he would be pleased to have brought into competition with those of Europe. I considered this particularly fortunate, not only on my own account, but because I was then just ready to leave for Europe and should shortly enjoy the opportunity of comparing them, as he desired.

The best foreign instruments seldom reach this country. The makers have always friends at hand who immediately seize upon whatever may be wrought in an eminently superior manner. I therefore thought that if I could reach and address the makers themselves, it would ensure a fair trial to all.

I regret that I was not long enough in London, or sufficiently favorably situated, to take advantage of the many kind inducements offered me to have a comparison there.

In Paris, however, many circumstances tended to hasten a trial, and particularly the presence there at that time of some of the latest, and reputedly the best English lenses. Moreover there were there many amateur microscopists.

The lenses on trial were as follows: those of Mr. Ross, of Messrs. Powell and Lealand, of Messrs. Smith and Beck, of London; those of M. Nachet of Paris; and those of Mr. Spencer of America. I regretted that none of the lenses of M. Oberhäuser —I mean his best—could be obtained at that time.

To secure perfect fairness, the lenses were all adapted to one mounting (a small one of Amici's pattern), and M. Nachet kindly superintended its correct adjustment.

The tests used were the most difficult that could be obtained, and that are now known—*Nobert's lines*, the *Grammatophora subtilissima*, and Amici's test, being a shell, one of the *Naviculæ*, and having markings more difficult to resolve than any other shell as yet discovered, if we perhaps except a Grammatophora, lately found at Providence, R. I. Now it is well known that the markings on the most difficult of organic test-objects can be made out by oblique light only, this obliquity was obtained to almost

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* The notice of the trials at Paris, given by Dr. J. L. Smith in vol. xi, p. 277 of this Journal, had not been seen by the author when this was written.—Eds.

any desirable extent, by the use of Amici's prism, which gives a wider angle than the prism of Nachet, or any other similar means used. The claim for superiority was soon found to lie between the lenses of Mr. Ross, Mr. Spencer and M. Nachet. Those of the other English makers were not, I was well convinced at the time, fair specimens of their skill, and as you will soon perceive, a subsequent experience justified this view.

With Nobert's lines it was thought that there was not a very marked difference between the three lenses above mentioned. At any rate as we could not all see alike, it was not regarded as being any especial test in this case.

The markings on both the *Grammatophora* and Amici's test, could be made out by all three, but certainly most distinctly and sharply defined by Ross and Spencer,—the field of Nachet not appearing quite as clear and light.

Between Ross and Spencer on the test of Amici, there did appear to be but very little difference, although I am free to say that if there was a choice of sharpness of definition, it was in favor of Ross.

On the other hand, with the *Grammatophora*, the opinion oscillated as much in favor of Spencer. So that with these two supreme tests, there appeared really to be no particular choice between Spencer and Ross, but as usual in such matters, the owners of the lenses felt no disposition to exchange with each other.

The working of Nachet's lenses, although they did not come up fairly with those of Ross and Spencer, was most excellent; and quite remarkable, considering what has hitherto been attained by the French opticians. Their excellence was also perceived in their great focal length, and other fine working qualities to which I shall soon allude. Moreover, although the results obtained upon organic particles, such as blood and other corpuscles, were in about the same ratio as the other tests, yet with these especially the lenses of Nachet claimed great credit for their clear achromatic power, representing the color of the particles in as nearly their natural condition fully as finely as any lenses I had before seen.

The main result of the trial was, in this case, the same in one particular as in other trials I have made, viz., to elevate our opinions of the capabilities of the lenses employed, it matters not by whom made. And if it was with much astonishment that the French opticians viewed the lenses of Mr. Spencer, I am sure that it was with no less wonder that some of our countrymen present saw the excellent glasses of Nachet. But to all it must be a cause of greater astonishment and admiration, that one self-educated, and who had had none of the experience of Europe, should make lenses fully equalling those of Europe's best artists who have been educated to the trade from their earlier days.

The lenses of Powell and Lealand did not, as I have before said, meet my anticipations; but since then I have met with better, and as bearing upon another comparison of lenses, I will as briefly as possible relate what happened. Some time since while in Philadelphia I had the good fortune to see some very recently imported English lenses, in the possession of microscopists of that city, who are too well versed in these matters to tolerate any but the most superior glasses. Those of this character were from Powell and Lealand.

Another comparative trial being suggested, all the lenses were adapted to a large fine English mounting, and it was thought best to test them by direct light and with the podura-scale, the greatest superiority resting of course upon the clearest and sharpest definition of the markings on that object. The $\frac{1}{12}$th inch objectives were used.

It was evident at first that the angle of aperture of Spencer was wider than that of the others, a larger field and more light being of course the result. As to sharpness of definition the opinions oscillated as at the other trial in Paris, first to one and then to the other, as they always must when lenses of great superiority approach so near to each other. But the impression left at last upon the mind seemed quite in favor of Spencer, as expressed afterwards by one who appeared equally capable and impartial in the matter. "They are fully equal to the best imported objectives I have seen, and I will not say that they are not a little better. I am inclined to believe that they are."

It may seem strange to some, that the direct light was used in this instance as a trial of the lenses. But it appears to me that the merits of a lens are as well if not better exhibited by this as by the indirect illumination. For in this case you have the degree of perfection with which it transmits light, without so much reference to the comparative angle of aperture, as to its capability of separating closely approximate rays emanating from an exceedingly minute yet methodically marked object. Such an object is a good scale from the Podura; and where several microscopists are together and can see the same scale with the different lenses, and can notice the difference of sharpness of definition, the capabilities of the lenses can be very impartially and correctly obtained. Some may urge that with any first class lens, the whole structure of the scale can be made out; this is very true, but this structure admits of being seen with different degrees of distinctness.

Moreover when lenses approach each other pretty closely in excellence, a difference may be perceived in distinctness of definition upon a well known object when seen by *direct* light, whereas that difference might well be disputed if those same lenses were made to bear upon a surface, the markings of which are with the utmost difficulty, or not at all, seen by indirect light.

But there is another reason which I wish to urge in favor of *direct* light being used in comparative trials, where instruments are together. Every one is aware of the fact, that in practising with his own instrument at different times, upon test-objects with *oblique* light, there are at times when with a certain obliquity, the test appears most excellently well brought out, while there are other times when apparently with the same amount of light and obliquity, the test is seen scarcely at all. Now all this arises from a slight yet real difference of the manner in which the object is illuminated, which, although otherwise imperceptible, causes that deficiency of a perfect shadow so essential to a clear definition. Now in a trial of instruments at a distance apart, this mode cannot be pursued, because a difference of distinctness must be *seen* and cannot be expressed; but I am the more persuaded that the comparative superiority of instruments, widely separated and upon different mountings and with dissimilar modes of illumination, cannot be even approximately obtained. I have seen lenses when tried upon a certain mounting cast aside as inferior to others upon a different mounting, whereas, subsequently when they both were put upon a single mounting befitting each, the former were found the superior.

I have thus informed you of the results of the comparative trials of Spencer's lenses at which I have been present; and when we regard the untutored labors of Mr. Spencer as thus coming so successfully into competition with those of the long experience of the first artists of Europe, we may well look upon our countryman with pride.

Before I close I will allude to the general character of microscopes of different makers, as it has appeared to me during the favorable opportunities presented at these different trials.

As a whole, the English instruments are very fine, and from no other makers can be obtained such exquisitely wrought brass mounting, united to quite excellent lenses. But they certainly have the objection of want of simplicity which makes them unwieldy, and almost fixtures wherever they may be placed, and attaches to them a price that places them beyond the reach of many who would use them best.

Moreover I cannot think their mountings so well suited for real work as some others; but they are most excellently adapted for that class of microscopists who are not desirous of being workers so much as of being amateurs in this department of science.

And although there are many times when all the nice mechanical arrangements of an English mounting may be almost indispensable, yet the man who does the real work, and from the labors of whom this science is to progress, will not use them once in a hundred times.

But if complexity is the excelling point with the mountings of English opticians, the opposite is true with those of the French,

for their object appears to have been to combine the greatest simplicity with working qualities.

This is very desirable because it insures several other important conditions, not to mention an incomparable cheapness, thus bringing them within the means of any one who would study this subject; it makes them portable, easily rigged, and not at all liable to derangement with the longest journeyings. But while I say this, let me add, that I think the mounting is rather too simple—in other words, I think it might be so altered, or have additions, that would increase its power of showing the capabilities of lenses, at the same time not infringing upon its working qualities. (Let me here say in parenthesis, that both M. Oberhäuser and M. Nachet are now directing their attention to this point.) I have here referred only to their mountings; their lenses have peculiarities worthy of notice. From what has been said, you will perceive that I do not think the French lenses equal either to the English or to those of Mr. Spencer. In working them they have sought every way to give them *ordinary* working qualities, their angles of aperture are narrow, which insures a long focal distance and a *flatness* of field not often seen in other instruments. This is particularly true of those of M. Oberhäuser, and combined with his *platine tournante*, is the cause of his well-merited success.

This class of instruments have certainly done more than any other for building up microscopical science, (which is not made up of the study of test-objects.) For working qualities upon *ordinary* objects, and particularly in many departments of natural history and pathology, requiring the use of from 300 diameters to quite low powers, they are very desirable, and answer the purpose of most other instruments with but half the cost.*

There are very many people who have a taste for pursuing microscopic studies, but it is not all of these who would like to follow the subject into all its most intricate departments; they would prefer to be pilgrims to a certain extent in the paths others before them have made, rather than pioneers on unbeaten tracks; such do not require the very best instruments.

It appears to me that those who wish to go beyond present microscopy, and investigate points of a very doubtful nature, will not succeed perfectly with the lenses of Oberhäuser or Nachet. Not only because their high powers lack a sharpness of definition, but because their powers are not sufficiently high for such studies. Oberhäuser's highest power is 800 diameters, Nachet's 1100. And even with these the darkness of the field causes them to be seldom used; and I have found these powers not ad-

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* In proof of this assertion, I may mention that I saw on M. Oberhäuser's books, more orders for instruments from London and other large cities of Great Britain than elsewhere.

equate to the successful study of some points in Cytogenesis and Spermatology.

In regard to a comparison between the instruments of Oberhäuser and Nachet, I cannot admit, as have some of my friends, the great superiority of the latter over the former, that is, with corresponding powers. Nachet works lenses having some 300 or more diameters more than those of Oberhäuser—besides with his best, the angle of aperture is wider and of course the field larger.

But still I have been unable to perceive that Nachet's lenses have a whiter field, or define objects more sharply than those of his tutor. I found many of the best microscopists and naturalists in Paris, who affirmed that as yet they had not seen fit to give up Oberhäuser for Nachet.

It now remains for me to say a word or two about Mr. Spencer. He is now a rival at least of the best foreign artists, and from what has been said, you cannot think it strange that they are fast acknowledging him as such. He has taken up the subject practically and experimentally, going over the whole ground for himself and learning its complete condition. It has been a source of wonderment to foreign opticians, how he could obtain such wide angles of aperture with his lenses and yet having the generally accompanying errors of chromatism and spherical aberration so carefully corrected; in fact Mr. Ross, in speaking of this subject to me, said, he thought that Mr. Spencer must have some mode of working glass as yet unknown to other opticians.

I think it true that the best English opticians and especially Mr. Ross, have wrought the finest European glass to its utmost capacity. Now the secret of success with Mr. Spencer is, that he makes his own glass, and after much experimenting, he has been so fortunate as to produce a form capable of being wrought with a very wide angle of aperture, yet with no more than the ordinary liabilities to chromatism and spherical aberration. This is the great point to be sought, and in his lenses recently made, I think he has been quite successful, much more so than with those made some three or four years since.

The advantages of such a wide angle of aperture, with a correction of the above errors, cannot be appreciated except by use of the lenses. The size of the field being very much increased, one is able to perceive the whole object instead of a single portion—and when you wish to view all the relations of an object in conjunction, or where it is to be sketched—this is a qualification of much value. Moreover the flood of light that the glass receives, emanating from every part of the object observed, renders the latter very much more distinct, and its structure therefore can be much better made out. This is very noticeable and its great advantage will be quickly perceived in microscopical pathology, in the study of sections of tumors, &c., and in the determination of the structure of minute animals in natural history.

Then again, such an abundance of light removes much obscurity from, and renders the use of, very high powers, quite available. And the power of 1500 diameters with Spencer's lenses is quite as clear and distinct as one-third that number with the French and many English. Every one knows how much better it is to be able to control the amount of light by a diaphragm, than to have the lenses control it for you. These are the grand merits of Mr. Spencer's lenses, which are the better shown off by the very excellent manner in which they (the lenses) are mounted. But with these manifold advantages, there are some disadvantages which have quite naturally resulted from the mode of lens-working pursued by Mr. Spencer. The lens being wrought with an angle of aperture, at the expense of its aplanatism, the focus is made, in the high powers impractically short, so that although, for instance, one may be using or wish to use the $\frac{1}{1\frac{1}{2}}$th objective of 140° or 150° angle of aperture, with the advantages of much light, &c., he will find that scarce any but objects specially prepared with the thinnest of covering glass, can be placed beneath it. With one who wishes to *work* with his lenses this is a serious difficulty, and I have thought, that unless this can be remedied, the possession of high objectives having more than 130° angle of aperture is not desirable for working microscopists. The attention of Mr. Spencer has been directed of late to this point, and it would appear that after some experimenting, he expects to go even *beyond* the solution of this difficulty. In a recent letter, answering some inquiries on this subject, he makes the following remarks:—"The remark you made that an increase of angle of aperture tends to shorten the working focus, is true of the present formulas. I do not remember that I mentioned this subject in a former letter, at any rate, my attention has been turned to it, and sometime since I began an objective under a new formula, the express design of which is to obviate this defect and to secure a working focus—for even a $\frac{1}{2\frac{1}{0}}$th or $\frac{1}{3\frac{1}{0}}$th inch objective, equal to the common $\frac{1}{1\frac{1}{2}}$ths. I think this can be done and retain the maximum angle of aperture. It does not follow that an increase angle of aperture interferes with the corrections of figure and color to such an extent, as to set the skill of the artist at defiance. It doubtless increases the difficulty of *investigation*, and to some extent the *execution*."

Such news is more than welcome to all lovers of microscopic science—and considering what has already been accomplished, we can look forward with both hope and pleasure to the time, not far distant, when complete success shall have crowned the labors of our countryman.

Trusting that the interest of the subject will be something of an apology for the length of this letter, I am yours truly,

W. I. Burnett.

Boston, May, 1851.

Art. IX.—*On the Connection of Chemical Forces with the Polarization of Light;* by Nevil Story Maskelyne, Esq., M.A.*

Any facts which can throw light upon the ultimate molecular structure and condition of chemical compounds, cannot fail of possessing interest of a high character, as well for those whose thoughts only casually dwell upon questions of physical science, as for the mathematician and the chemist. To the mathematician, indeed, they would, if completely unfolded, supply the data for him to undertake the resolution of the questions of chemical combination and chemical change, by treating them as problems involving the action of mechanical laws; to the chemist, the acquisition of such knowledge would be the removal of some of the profoundest difficulties of his philosophy: but such knowledge is only to be sought in the most difficult paths of the whole range of science. The question of the connection of chemical type with crystalline form, the fruitful cause of so much contention among mineralogists as to the questions of mineral species, is one on which we have no complete and sure knowledge; for the facts of dimorphism show, that implicated with this question are the actions of other forces, such as electric condition, and above all the mysterious molecular alterations induced by heat. Another direction in which such inquiries have been pursued, has been in tracing the phenomena resulting from the property possessed by many bodies, of modifying a plane-polarized ray of light, by what is termed circular-polarization. This property, from its being proved to be, in a large number of cases, an expression of the *molecular* structure of the substances, and as such inseparable in many cases from its chemical existence, may be taken, whenever this can be shown to be the case, as an evidence of its individuality, and may be used to determine the question of the permanency or transitory character of the molecular type of the substance. The information thus gained may be but vaguely defined, and the truth but darkly seen, yet does it nevertheless afford a valuable and interesting point of view for studying the molecular nature of bodies.

M. Biot has been for forty years enriching chemico-physical science by a series of memoirs detailing the results of his study of these phenomena. He has there shown the value of this means of tracing changes in chemico-molecular constitution.

M. Pasteur has carried forward this inquiry into a new channel by tracing a connection between this property in substances, of circularly polarizing light, and their crystalline character.

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* Proceedings of the Roy. Soc., London, Monday, March 28, p. 45.

But as it would be impossible to explain the nature of his investigations, or their results, without a preliminary knowledge of the meaning of the terms, "circular polarization," and "hemihedrism," it was necessary first to enter a little upon the explanation of them.

Accordingly a ray was explained as being a direction of light, having no relations to space which differed from each other in directions perpendicular to its length. Thus without complicating the subject, by using the language of the beautiful wave-theory, a ray might be imagined as a cylinder of minutest diameter but indefinite length. When such a ray is reflected at a certain angle from glass or such like substance, it is split into two; one going into, and through the glass if it be not opaque, the other being reflected from it. These two rays no longer possess the same "absence of sides" as the original ray. For the one has been as it were flattened down to a "strip," while the other has also been flattened similarly into a "strip," but the latter strip is at right angles in regard to its "flattened plane" to what the other is. A similar bifurcation of the ray is produced in the interior of what are called doubly refracting crystals. This bifurcation and flattening of the ray is termed "plane polarization" of it; and it is so far a true instance of polarity—as that the two rays have equal and similar properties in opposed directions.

This was exhibited by the lime-light. The double image of a small round hole formed by a crystal of Iceland spar was thrown on a screen, and each beam shown to be most capable of reflection in a plane in which the other was incapable of being reflected at all. The action of the tourmaline as a doubly refracting crystal which absorbs one of the rays was then explained; and it was shown that the position of the tourmaline in which it intercepted one ray entirely, was exactly the position in which it gave the other ray free passage. The optic axis of a crystal was then defined to be a direction in it along which the light could pass through the crystal without undergoing any change whatever. The central ray of a polarized beam of light, traversing a piece of calc-spar along its optic axis, was shown to be intercepted or transmitted by a tourmaline, precisely as if the section of the crystal of calc-spar were away.

An exception was however stated to exist to this law of the neutrality of the optic axis. When a section of quartz, cut so that the beam could career along its optic axis, was put in the path of the polarized ray, it was found that instead of permitting the ray to be eclipsed by the tourmaline when this was placed in the position to eclipse it, that ray on the contrary fell on the screen endowed with beautiful color; and furthermore that the revolution of the tourmaline induced the most brilliant succession of colors, in the order, in the instance exhibited, of red, plum-

color, blue, green, orange, red. It was shown, however, that another specimen exhibited these colors in the reverse order of red, orange, green, blue, plum-color, red; in which order the former specimen of quartz produced these colors when the tourmaline was turned in the *opposite* direction. Hence these are termed right and left-handed polarizations. The whole of these phenomena were attributed to a complicated set of movements of the light within the crystal, the *resultant* of which was practically a rotation of the plane in which the ray was capable of being reflected,—so that the thicker the crystal, the further round the tourmaline had to be turned to permit the ray to pass it, or to be eclipsed, as the case might be. The opposite order of the colors was explained by the fiction of supposing the one to be the effect of a left-handed thread to the screw and the other of a right-handed thread characterizing the spiral in which the plane of polarization was supposed to rotate. Of course this was only a popular way of explaining the phenomenon, it being really due to a more complicated series of movements which were explained by Fresnel in the most triumphant manner by the wave theory.

The color was accounted for by the idea of the red following a longer spiral (having a coarser thread to the screw) than that of the orange, this than the yellow, and so on up to the violet. Without the tourmaline in front all would emerge and form white light; but the tourmaline only allows such rays to pass it as are capable of passing it in its particular position; i. e. only such, the rotation of whose plane has brought them round to the position of the plane in which the tourmaline lets the light through.

The singular fact of amethyst being a combination of alternate layers of right and left-handed quartz was then exhibited, both by throwing the image of the alternate layers on the screen, and afterwards by showing that the general effect of a traversing polarizing beam was to produce a neutrality of action. Other substances, however, produce phenomena of circular polarization. Uncrystallized, fused tartaric acid, and barley sugar, &c., produce them; and these bodies when dissolved, and many more in the form of liquids also, do so, some of which were exhibited. But the silica of which quartz consists entirely loses this property when divested of its crystalline character, whether artificially or in its natural state, as calcedony, opal, &c. All other bodies retain it so long as their chemical molecule retains its individuality of character.

The next point to be made clear, was the meaning of that form of crystallographic development called "Hemihedrism." Haüy's great law was, that similar edges or angles were always similarly modified. The nature of similarity in edges or angles was then pointed out, and the general idea of many crystallographers of a sort of nucleus or primitive form existing on which the crystal

was formed, was explained, as also the nature of the development of such a crystal by the modifications placed on the edges and angles according to the law before mentioned. But the exception to that law was not less remarkable for its generality of character than the law itself. This exception consists in the fact that very often crystals are found in which not every similar edge or angle was modified, but where every *alternate* similar edge or *alternate* similar angle was so. This circumstance was then illustrated by the actual truncation of some models; and it was shown that such alternately developed or *hemihedral* crystals may be *right* and *left*, the upper terminal modification being to the right in the one case, and the corresponding and similar lower terminal modification being then to the left, while in the other case they are exactly the converse. Hence, one crystal is, as Pasteur describes it, "*non superposable*" to the other: the one is as the image of the other reflected in a mirror, as the right hand is compared to the left.

A beautiful connection was then pointed out, as established long ago by the acute observation of Sir J. Herschel, that the plagihedral facettes of quartz indicated, by their relative positions on the crystal, the direction in which the crystal would rotate the plane of polarization. The crystallographic character of these facettes was then pointed out, and their connection shown with this hemihedrism. But the most beautiful instance of the connection of hemihedrism in crystals with the direction of the rotatory power of the substance of which they are composed is afforded by the recent discoveries of Pasteur, which may now be almost traced to a law, enunciated thus: that where a substance is hemihedric when crystallized, and possesses the rotating character, the direction of the rotation is indicated by the nature of the hemihedrism.

Paratartaric acid was then introduced. It was described as extremely like tartaric acid in its chemical reactions and identical with it in composition. It was similarly formed to the latter, and was found only one year in the cream of tartar of the wine of the Vosges. Pasteur separated the crystals of the Paratartrate of soda and ammonia into two several sets; the one set he showed to be hemihedric to the right, the other set to the left. The former proved to be the salt of an acid rotating to the right, the latter of one rotating to the left. On examining these acids they were found in every single property, but this rotation, identical with one another and with tartaric acid. Yet when mixed they formed again the Paratartaric acid, which, like the amethyst, is without any action of a rotatory character, and the difference of which from the other two acids was then exhibited by the precipitation by the latter of a salt of lime which did not render either of the former turbid.

Mr. Maskelyne then detailed the experiments of M. Pasteur on malic and aspartic acids and asparagine, and showed how all of these could be understood to contain chemically a molecular unit common to all these and perhaps to tartaric acid, and only modified a little by the super-position as it were of other substances, in combination with it, upon the extremities of its molecule.

He also dwelt on the possibility of the Paratartaric acid being a quadribasic as the tartaric acid is a bibasic acid: it being on this view a conjugate acid consisting of the two united tartaric acids. He then invited attention to the interesting nature of M. Biot's investigation of the action of tartaric acid in solution in water, and he showed that here the acid must be supposed capable of combining with an indefinite or indeed an infinite amount of water, while in other cases again, bodies (such as sugar for instance) exercise no effect upon the water and do not seem to *combine* with, but only to be dissolved in it. The former is an instance of a *continuous* and not *intermittent* sort of combination: and though we need not anticipate a recurrence of the controversy of Berthollet and Proust, yet this shows us that the actions of quantity or mass so dwelt on by the former are not without a great significance; and that the power that can thus enable us to determine such important points in chemical statics, is well worthy of the attention of the philosophic mind.

Dr. Bence Jones permitted a Saccharimeter apparatus of Soleil's, on the double-quartz-plate principle, to be exhibited, and explained its use. Mr. Tennant also exhibited a mass of quite transparent Iceland spar, and a beautiful crystal of plagihedral quartz.

Since the delivery of the lecture, a letter has been received from M. Pasteur stating that he had forwarded for exhibition at this lecture and in illustration of it, all the finest specimens of the crystals which he has produced, which are further illustrated by models and diagrams. They are the same as those which were exhibited at the Academy of Sciences at Paris, and the liberality of M. Pasteur's act will be appreciated by members of the Royal Institution, when they are reminded that the Paratartaric acid of which they are the products is impossible to be obtained, from its having only once been accidentally formed, and that these specimens therefore consist probably of the only large accumulation of this body in existence.

Art. X.—*On Atmospheric Magnetism;* by Prof. Faraday.*

On a former evening (January 24,) it was shown that oxygen gas was magnetic, being attracted towards the poles of a magnet; and that like other magnetic bodies, it lost and gained in power as its temperature was raised and lowered, and that the change occurred within the range of natural temperatures. These properties it carries into the atmosphere; and the object, this evening, was to show how far they might be applied to explain certain of the observed variations of the terrestrial magnetic force.

If a source of magnetic power be considered (as a magnet), it presents us with a system having polarity; and if the parts which are called the poles be taken as representing the most concentrated condition of the polarity, then the contrary polarities, manifest externally in relation to the magnet, are perfectly definite, being exactly equal to each other. If the magnet be irregular in the disposition of its force, still the same definite character of the sum of the contrary polarities holds good.

External to the magnet those concentrations which are named poles may be considered as connected by what are called magnetic curves, or lines of magnetic force, existing in the space around. These phrases have a high meaning, and represent the ideality of magnetism. They imply not merely the directions of force, which are made manifest when a little magnet, or a crystal, or other subject of magnetic action is placed amongst them, but those lines of power which connect and sustain the polarities, and exist as much when there is no magnetic needle or crystal there as when there is; having an independent existence analogous to (though very different in nature from) a ray of light or heat, which, though it be present in a given space, and even occupies time in its transmission, is absolutely insensible to us by any means whilst it remains a ray, and is only made known through its effects when it ceases to exist. The form of a line of magnetic force may vary exceedingly from a straight line to every degree of curvature, and may even have double and complicated curvatures impressed upon it. Its direction is determined by its polarity, the two changing together. Its powers are such, that a magnetic needle placed in it finds its place of rest parallel to it; a crystal of calcareous spar turns until its optic axis is transverse to it; and a wire which is unaffected when moved in or along it, has an electric current evolved the instant that it passes across it: by these and by other means the

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* Proc. Roy. Soc., April 11, p. 56.

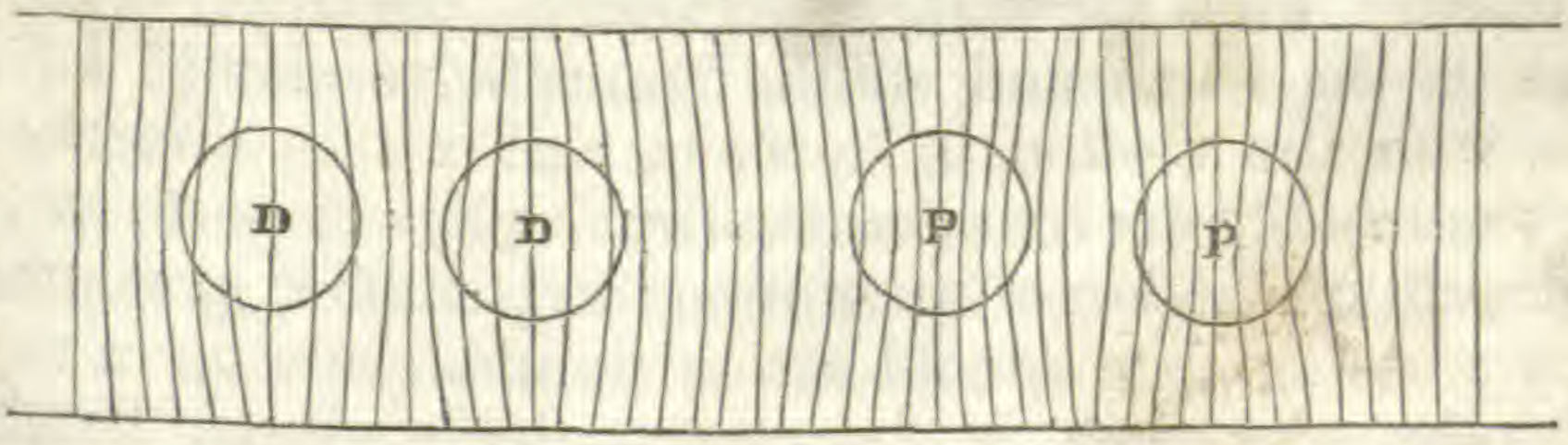
presence of the magnetic line of force and its direction are rendered manifest.

The Earth is a great magnet: its power, according to Gauss, being equal to that which would be conferred if every cubic yard of it contained six one-pound magnets; the sum of the force therefore is equal to 8,464,000,000,000,000,000 such magnets. The disposition of this magnetic force is not regular, nor are there any points on the surface which can be properly called poles: still the regions of polarity are in high north and south latitudes; and these are connected by lines of magnetic force (being the lines of direction) which, generally speaking, rise out of the earth in one (magnetic) hemisphere, and passing in varied directions over the equatorial regions into the other hemisphere, there enter into the earth to complete the known circuit of power. A free needle shows the presence and direction of these lines. In London they issue from the earth at an angle of about 69° with the horizon (being the dip or inclination;) and the plane in which they rise forms an angle of 23° W. nearly with true north, giving what is called west declination. Where the dip is small, as at the magnetic equator, these lines scarcely rise out of the earth and pass but a little way above the surface; but where it is large, as in northern or southern latitudes, they rise up at a greater angle, and pass into the distant realms of space, from whence they return again to the earth in the opposite magnetic hemisphere; thus investing the globe with a system of forces like that about an ordinary magnet, which wherever it passes through the atmosphere is subject to the changing action of its magnetic oxygen. There is every reason to believe that these lines are *held* in the earth, out of which they arise and by which they are produced, just as the lines which originate in a magnet are held by it, though not in the same degree; and that any disturbance from above affecting them will cause a greater change in their place and direction in the atmosphere and space above, than in the earth beneath.

The system of lines of magnetic force around a magnet or the earth is related by a lateral tension of the whole, analogous in some degree to the lateral tension of lines of static electrical force; both the one and the other being easily made manifest by experiment. The disturbance of the tension in one part is accompanied instantly by a disturbance of the tension in every other part; for as the sum of the external powers of a system, unaltered at its origin, is definite and cannot be changed; so any alteration either of tensity or direction amongst the lines of force at one place, must be accompanied by a corresponding change at every other. So if a mass of soft iron on the east side of a magnet causes a concentration of the lines of force from the magnet on that side, a corresponding expansion or opening out

of the lines on the west side must be and is at the same time produced; or if the sun, on rising in the east, renders all the oxygen of the air on that side of the globe less magnetic and less able therefore to favor the transition of the lines of terrestrial force there, a greater number of them will be determined through the western region; and even though the lines of force may be doubted by some as having a separate existence such as that above assumed, still no error as to the effects on magnetic needles would in that case be introduced, for they by experiment would be and are the same.

The power of a magnetic body as iron or oxygen to favor the transmission of lines of force through it more than other bodies not magnetic, may be expressed by the term conduction. Different bodies, as iron, nickel, oxygen, conduct in various degrees, and not only that, but the same body as iron or oxygen conducts in different degrees at different temperatures. When space traversed by uniform lines of magnetic force is occupied by a uniform body as air, the disposition of the lines is not altered; but if a better conducting substance than the air is introduced, so as to occupy part of the space, the lines are concentrated in it, and drawn from other parts as shown by P P, in the figure, or if a



worse conducting substance is introduced, the lines are opened out as at D D. In both cases the lines of force are inflected, and a small magnetic needle standing in them at the inflected part would have its direction changed accordingly. Experimental illustrations of these changes in direction are given in Mr. Faraday's paper in the Philosophical Transactions for 1851, Part I, Par. 2843, &c.

Now this by the hypothesis is assumed to take place in the atmosphere. Supposing it all at mean temperature, the lines of force would have the direction determined by the arrangement of the power within the earth. Then the sun's presence in the east would make all the atmosphere in that region a worse conductor, and cause it to assume the character of D; and as the sun came up to and passed over the meridian and away to the west, the atmosphere under his influence would bring up changes in direction like those shown in either D or D; it would therefore manifestly set a needle in a given latitude in opposite directions as it passed by; and as evidently set two needles in north and south latitudes in opposite directions at the same moment of

time. As the night came on and a temperature lower than the mean came up from the east and passed over, the lines of force would be inflected as in P or P, and a reverse variation of the needle to that which occurred before would now take place.

The natural effects of variation must be produced consequent upon the magnetic nature of oxygen and its daily variations of temperature is manifest; but whether they cause the observed variations, or are competent to do so, is a question that can only be decided after very careful enquiry. Observations are now made on the surface of the earth with extreme care in many places, and these are collated, and the average or mean result, as to direction and intensity of the earth's force, ascertained for every hour and season; and also many remarkable, anomalous, and extra results evolved. A theory of the causes of any or all of these variations may be examined first by the *direction* which the varying needle does or ought to assume, and then by the *amount* of the variation. The hypothesis now brought forward has been compared by the mean daily variation for all the months in the year at north and south stations, as Toronto and Hobarton, and at many others near to and far from the equator, and agrees in direction with the results observed far beyond what the author anticipated. Thus the paths described by the upper ends of free needles in the north and south hemispheres should be closed curves, with the motion in opposite and certain directions, and so they are:—the curves described by needles in north and south latitudes should be larger in summer and smaller in winter, and so they are:—a night or cold action should grow up in the winter months, and such is the case:—the northern hemisphere ought to have a certain predominance over the southern, because of its superior temperature, and that is so:—the disposition of land and water ought to have an influence, and there is one in the right direction:—so that in the first statement and examination of the hypothesis it appears to be remarkably supported by the facts. All these coincidences are particularly examined into and stated in the Philosophical Transactions already referred to. The next step will be to ascertain what is the amount of change in the conducting power of the air for given changes of temperature, and then to apply that in the endeavor to ascertain whether the amount of change to be expected is (as well as the direction) accordant with that which really occurs.

ART. XI.—*On Eupyrchroite of Crown Point, New York;* by CHARLES T. JACKSON, M.D., Assayer to the State of Massachusetts, &c.

THE specimens of Eupyrchroite which I have analyzed were sent to me by Mr. C. F. Hammond of Crown Point, and he writes to me, that one hundred tons of the mineral have been taken from the mine, and it is understood it is to be employed in the preparation of phosphates for agricultural use. This enterprise has followed the movement which Mr. Alger has made at my suggestion, in working the mine of phosphate of lime in Hurdstown, New Jersey, and I hope it will awaken the attention of mineralogists and geologists to other neglected or overlooked deposits of this valuable mineral, so desirable as a fertilizer, and so important as a constituent of the vegetable products used for food.

When the mode of managing this manure is generally known, there will be a demand for it that all our present known localities will not be able to supply, and therefore, every new discovery of any extensive deposit of it, will be hailed with pleasure.

I learn that measures have been taken to export this mineral to England, where it is most highly valued for agricultural use, particularly in the preparation of the land for the growth of hops. It is also extremely valuable in the preparation of the soil for other crops, all of which contain phosphates in considerable proportions. It appears that the exhaustion of wheat lands by incessant cropping, without adequately replenishing the soil by manures, is owing to the removal of phosphates from the soil. Our farmers should therefore look into this matter, and remedy the evil that an early want of attention to the chemical principles of agriculture has led them into. It is hardly necessary for me to say that burned or ground bones may be used for the same purpose as the mineral I am about to describe; nor will it be necessary to enter upon the discussion of the question as to the indispensable necessity of the existence of phosphates in food, which is to form flesh, blood and bones, for most men know that they have seven pounds of phosphate of lime in their bones, and nearly as much of other phosphates in the soft parts of their bodies. It is also known that the ashes of all cereal grains contain almost fifty per cent. of phosphoric acid, united with lime, potash, soda and magnesia, and that plants derive these phosphates from the soil, which contains generally but a very minute proportion rarely amounting to three-tenths per cent.

Description and Analysis.

This mineral was first described by Prof. E. Emmons in his Report on the Geology of New York, and was analyzed by Prof. Lewis C. Beck and published in his Report on the Mineralogy

of New York, p. 240; but his specimens differ somewhat from mine in their physical characters. It was named Eupyrchroite by Prof. Emmons in allusion to the beautiful emerald green light, which it gives out when thrown on heated iron, its phosphorescence being nearly equal to that of the chlorophane fluor spar of Connecticut.

The Eupyrchroite phosphorite occurs in botryoidal concretions, having a fibrous structure, and an ash-gray or bluish gray color, the concretions being made up of successive layers of different shades of color. Their surface is frequently covered with a delicate film of iron pyrites which scales off readily when scraped with the knife. Its Sp. Gr. is 3·053. Hardness 4½. Before the blowpipe phosphoresces with a green light at first, then gives the intense brightness characteristic of lime salts. It glazes on the surface at a high temperature, but does not melt. In the glass tube it gives out water, which is acid, and corrodes the glass. When thrown in powder on metal, heated nearly to redness, it exhibits a brilliant emerald green phosphorescence. Larger fragments decripitate strongly.

During its solution in chlorohydric or nitric acid, it effervesces slightly, carbonic acid gas escaping. The quantity of this gas was accurately determined by the proper apparatus. In preparing the mineral for proportional analysis, each fragment was carefully examined with a lens, to ascertain that it was free from accidental admixture with other minerals. It was reduced to impalpable powder by levigation, and dried at 212° F., and weighed while still warm. A sample of the mineral in coarse powder was used in the determination of the water contained in it. In the other steps of the analysis the methods as given by Rose were pursued, and the following results were obtained.

Lime, ...	47·230
Phosphoric acid, . . .	45·710
Carbonic acid, . . .	1·218
Lime, ...	1·554
Chlorine, ...	0·130
Calcium, ...	0·204
Fluorine, ...	0·599
Calcium, ...	0·855
Protoxyd of iron, . . .	2·000
Water, ...	0·500
	100·000

The fluorine as usual was expelled, and thus determined by difference, in the re-formation of phosphate of lime, after decomposition of the precipitated mixed phosphate of lime and fluorid of calcium, and its equivalent of calcium was deducted from the lime obtained as a sulphate of lime.

ART. XII.—*On the Recent Condition of Kilauea;* by Rev. C. S. LYMAN, including a letter from Rev. T. COAN, Missionary at Hilo, Hawaii.

IN an article on "Volcanic Eruptions on Hawaii," published in the ninth volume of this Journal, (May, 1850,) the geologist of the U. S. Exploring Expedition* has given a description of the topography of this remarkable volcano, together with some notices of its various eruptions since it began to be visited by foreigners. To this article the reader is referred for a general description of the situation and character of the crater of Kilauea, illustrated by a plan and section.

The writer of these remarks spent several days at the volcano in July and August, 1846—some six weeks elapsing between the two visits.

A letter has just been received from the Rev. Mr. Coan, the enterprising American missionary at Hilo, Hawaii, whose name has been so often mentioned in connection with this volcano, sketching briefly the history of Kilauea since he and the writer visited it together in 1846. The volcano lying within the limits of Mr. Coan's missionary field, (though forty miles from Hilo,) he often has occasion to pass it in his tours among his people, and thus has become more familiar, probably, with its various changes and aspects for the last fifteen years than any other individual.

Before giving Mr. Coan's letter, it may not be improper to remark briefly on the appearance of the crater at the time of the writer's visits in 1846.

At that time the volcano was represented by Mr. Coan as being in one of its more quiet moods. Indeed, the first view obtained of it on our arrival was so little attractive as almost to produce a feeling of disappointment. The less curious class of visitors sometimes experience this feeling so keenly that they turn on their heel at once and refuse to descend into the crater, fully convinced that they have been deceived by extravagant descriptions, and that nothing is to be seen that will repay them for the trouble. On reaching the brink of the pit, instead of loud detonations and billows of fire, the ear heard nothing save the murmuring of the strong northeast wind as it rushed over the precipice, and the eye saw nothing save a broad, deep, enclosed valley—an apparently sunken tract of the earth's surface—with a black level bottom, strikingly resembling an area of burnt prairie land, from the distant extremity of which were lazily rolling up a few clouds of smoke and vapor, as if the prairie-fire were not yet wholly extinguished.

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* See also Rep. on Geol. Expl. Exp., Chap. III.

At night, however, that part of the crater from which the vapors had been seen rising was lit up with what seemed a glowing line of fire. This was the part of the volcano that has generally been called the "Great lake." Save at this point, the volcanic fires were nowhere visible from the upper bank, and only in a few other places were there seen indications of their existence in the jets of steam that were issuing from crevices in the lava. These steam jets, on further examination, were found to exist even out of the crater on the upper bank, in the vicinity of the huts in which visitors find temporary lodgings.

The northern sulphur banks we found to be essentially in the same condition as described by previous observers—lying under a bluff wall of rocky lava from which they are separated by a crevice or chasm, out of which constantly issue steam and sulphureous gases, depositing on the rocks, and even on the branches of certain species of vegetation, beautiful incrustations of sulphur and other substances.

Our place of descent into the crater was the usual one over the broken declivity at the northeastern extremity. On reaching the bottom, we found it difficult, at first, to identify any thing answering to the "Black ledge" spoken of in the narrative of the Exploring Expedition, and by most previous observers. In 1840 the crater, as described by Capt. Wilkes, and by Mr. Dana in the article already referred to, consisted of a sort of pit within a pit—a broad depression in the earth's surface, first by an almost perpendicular wall 650 feet in depth to the Black ledge, and then—leaving the ledge or terrace one or two thousand feet in width all around the crater—by a second abrupt descent of 350 feet or more to the general level of the bottom. In this lower area in 1840, were various pools of fluid lava, the principal one, known as the Great lake, lying towards the southwestern extremity, and measuring at that time 1000 feet by 1500 in diameter.

The terrace or Black ledge thus described we found almost obliterated, the whole interior of the pit having been filled up nearly to a level with it, and in some places from fifty to more than one hundred feet above it. By measuring a base line on the ledge and taking angles with a quadrant, the height of the northwestern wall of the crater above the terrace was computed to be 680 feet, which agrees nearly with the measurement of the Exploring Expedition, and shows that this part of the floor has not been elevated since 1840. Previous to the great eruption in that year, however, there is good evidence that the entire area of the crater, including the former Black ledge, had been repeatedly overflowed, and thus the ledge of the Exploring Expedition, (and which has remained unaltered to the present time,) placed at an elevation of many feet, (some observers estimate it at two hundred or more,) above the Black ledge of Douglass and the earlier visitors.

At the interior margin of what has been described as the Black ledge, especially on the northeast and east, our attention was particularly attracted by a continuous ridge more than a mile in length, consisting of angular blocks of compact lava, resembling the debris at the foot of a range of trap or basalt. This ridge rose on its outer or eastern face often to the height of fifty or one hundred feet, especially towards the south where it approached the Great lake; and generally it left a space, or "canal," as it has been called, between it and the ledge several rods in width, and in some places forty or fifty feet in depth. This was apparently what had once constituted a *talus*, or accumulation of debris on the floor of the crater at the foot of the nearly perpendicular precipice of the Black ledge, at a time when the floor was three or four hundred feet below its level at the date of our visit. That floor, with its margin of debris having been subsequently elevated, partly by upheaving forces from beneath, and partly by successive overflowings from the Great lake and other active vents formerly existing, at length rose higher than the precipice at the foot of which it was accumulated, and presented to view the rocky ridge we have been describing—a phenomenon that seems inexplicable on any other hypothesis than that of the bodily upheaving of the inner floor of the crater. The fact of such elevation is further evident from the appearance of these ridges on their inner or western slope. This side was broken and precipitous like the other, but of a much inferior altitude. Indeed, the altitude gradually diminished towards the southern portion of the ridge, till in the vicinity of the Great lake, instead of a ridge it became simply a precipitous bluff facing the east, from the top of which spread out an uneven plateau occupying the whole central portion of the crater north of the lake, and elevated more than a hundred feet above the Black ledge. This wall was too steep and high to be scaled by our party, but the plateau just mentioned was subsequently visited by the writer, and at its southeastern limit so precipitous was the descent, that stones hurled from the hand cleared the foot of the bluff, and occupied nearly three seconds in falling—which would give for the perpendicular elevation the amount that has just been stated.

Thus the entire portion of the crater within the black ledge appears to have been filled up, or elevated, on an average more than 400 feet between 1840 and 1846; and from the testimony of subsequent observers, it would seem that the process of elevation, especially in the neighborhood of the Great lake, has been going on with greater or less efficiency to the present time.

The "canal" spoken of, or the space between the inner margin of the old Black ledge, and the outer margin of the central portion of the crater, was so named from the fact that formerly, when it was 200 feet deep or more, molten lava had been ob-

served by Mr. Coan flowing into and along it from the great lake. On one occasion, indeed, the glowing stream was seen by him to plunge in a fiery cataract down a precipice fifty feet in height—presenting a sublime spectacle. By these successive overflows this space had, in 1846, become nearly filled up, and in many places the former "canal" was entirely obliterated.

The Great lake in 1846 was by approximate measurements computed to be about 2400 feet in diameter from N.E. to S.W., and 2000 in the transverse direction. Its surface was nearly on a level with the Black ledge and with that portion of the floor of the crater between it and the ledge. It was surrounded on all sides except the northern or northeastern, by a rim or embankment of lava from ten to twenty feet in height, built up apparently by repeated partial overflowings and the marginal deposit of clots and jets of lava thrown up by incessant ebullition—somewhat after the manner of the ridge of ice congealed around a fountain, or accumulated along the margin of a river. On the N.E. the lake was bounded by a high broken and almost inaccessible tract of lava, rising at length into the elevated plateau before described. When visited by the Exploring Expedition in 1840, the surface of this lake was between three and four hundred feet below the Black ledge, and measured only 1000 by 1500 feet in diameter. Consequently in six years it had not only increased in size, but it had actually risen in height as much as it had been previously depressed by the outdraining of lavas in the eruption of 1840. This gradual rising of the solid embankment of the lake contemporaneously with the lake itself, together with the filling up of the whole interior of the crater, is doubtless to be attributed to the combined effect of repeated overflowings, together with the upheaving agency of subterranean forces.

The surface of the lake was constantly in a state of gentle ebullition, yet in consequence of the rapid cooling, becoming covered repeatedly with a thin crust, which crust was again constantly breaking up, and redissolving in the molten mass. The clots or jets of gory lava thrown up by the escaping gases often ascended from five to fifteen feet, and there was a general motion of the surface of the lake slowly towards the southwest. This motion was observed first on the western side, and afterwards at several different points on the eastern. A large stick of wood thrown on the lake, at a point where the ebullition produced a sort of eddy or rolling in of the lava, was immediately taken out of sight, but the next instant a more violent ebullition, together with a sudden outburst of flame and smoke told how almost instantaneously the stick had been transformed into charcoal.

The surface of the fluid lava was some ten or fifteen feet below the top of the embankment, and inaccessible by any means at our command for dipping it up. The spectator, however,

could stand on the very brink of the enclosing rim within a dozen feet of the contents of the great cauldron, with only a handkerchief or hat held before the face to guard against the effects of the intense heat. The non-conducting power of lava in respect to caloric was strikingly shown by an incident that occurred during our visit. A Panama hat was accidently blown from its wearers head, and deposited by the wind on a thin crust of lava that had just stiffened and turned black on the surface of the lake. Though all expected to see it instantly in flames, it was slow in becoming charred, and five or six minutes elapsed before it finally took fire and disappeared. In 1846 the only lake or pool of molten lava in all the crater was the large one we have been describing; all the others noticed by previous observers had become extinct. Near the center of the crater the writer visited a depression of great extent, and perhaps a hundred feet in depth, very irregular in surface and outline, and full of fissures and chasms from which volumes of steam and vapor were issuing. This may have been the seat of one of the large active centers of liquefaction described by former visitors. Not far from this place, at the bottom of a chasm forty or fifty feet deep, lava of a cherry red hue was discovered, and the orifice of the pit was lined with beautiful incrustations of sulphur. A very accessible and interesting point in the crater was about a mile north of the Great lake, where a small cone or dome ten or twelve feet high presented almost exactly the appearance of an artificial furnace or oven. The walls of the dome were scarcely more than a foot thick, and through two openings, the one a foot and the other half a foot in diameter, the interior was revealed of a glowing white heat, and by throwing pieces of lava into these orifices they were seen to fall into the pasty, semi-fluid mass ten or fifteen feet below. This furnace was in full blast at the writers second visit, six weeks after the first.

The exterior walls of the crater seem to the eye at a distance to be nearly perpendicular. But this is far from being the fact, except on the northern and western sides. The writer during the two visits referred to descended into the crater, or emerged from it, at four different points—first at the usual place of descent on the northeast; again by climbing up the slope where lava of the eruption of 1832 flowed down from the very top of the precipice to the bottom at an inclination of not far from 45°—a most hazardous place of exit; next down a gentle slope to a sunken plateau or terrace lying above and back of the sulphur banks on the southeastern side of the crater, and from this terrace by an equally gentle slope to the bottom; and lastly down the easy sandy declivity at the southern extremity of the crater, where the angle of inclination is not over twenty-five or thirty degrees. From numerous positions on the margin and within the crater compass

bearings were taken for the purpose of fixing the topography of the points of principal interest, and from these and other observations were derived the few data mentioned in the present paper.

During the six weeks intervening between the two visits of the writer almost no perceptible change had taken place in any part of the crater, except that the Great lake had apparently risen four or five feet. Two or three months afterwards, the lake overflowed its embankment, and subsequently retired to its former level.

Since 1846, as will be seen from the communication of Mr. Coan, great changes have taken place, and the general aspect and modus operandi of the volcano have undergone various revolutions. The Great lake has ceased to exist as a cauldron of boiling lava. A huge dome surmounted by cones of eruption has been formed over it. The general activity of the volcano has suffered apparently a large diminution, and the crater has become gradually choked up. The latest report from the Islands, of a date subsequent to Mr. Coan's communication, speaks of a new eruption having occurred at Kilauea, but the extent and character of it are not described.

Mr. Coan in his recent letter to the writer, remarks as follows:

Letter of Mr. Coan on Kilauea, dated Hilo, January, 1851.

You recollect the aspect of this unique volcano at the time we visited it in 1846. My next visit to the crater was in July, 1847, in company with Capt. DuPont and several officers of the U. S. ship Cyane. No essential changes had occurred in the bottom of the volcano during this interim, except that the Great lake had filled up, had overflowed a considerable area around its rim, was still full and in an active state.* The boiling of the lava was intense around most of its circumference, and at many points over its surface. Access to the red-rolling fusion was comparatively easy, so that by carefully watching and dodging its fiery jets we could dip up its viscid matter with sticks or ladles. Several gentlemen imbedded coins in the lava while in fusion and kept them as specimens. Silent and successive overflowings took place from time to time during this year, considerably elevating all the area in the vicinity of Halemaumau, or the lake, but not affecting the other and larger portions of the crater. I think it was about the beginning of 1848 that the Great lake was first noticed as crusted over with a thick stratum of lava;

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* In a letter dated Dec. 7th, 1846, Mr. Coan says: "Visited the volcano a few days ago." "Found the lake full and active. Dipped up the molten lava with our canes."

and this stratum was soon raised into a dome some 200 or 300 feet high over the whole lake; traversed here and there by rents and fissures, and studded by an occasional cone. Occasionally the visitor or the passing traveller would descry, through these fissures, the glowing of the subterranean fires, and now and then the gory mass would be pressed sluggishly through these chasms, or driven up with more force through the several chimneys, apertures, or orifices of the dome. These eruptions rolled in heavy and irregular streams down the sides of the dome, spreading over its surface or cooling at its base. Thus the dome, as it now exists, has been formed by the compound action of upheaving forces from beneath and of eruptions from its openings, forming successive layers upon its external surface. During most of this year, however, (1848,) an extraordinary *inactivity* prevailed throughout the crater, so that visitors chided the long slumbers of the goddess, and were impatient with her drowsy propensities. During the summer and autumn of this year, when I was at Kilauea, there was no fire to be seen, even in the night. Old Vulcan seemed to have forsaken his furnace, buried his fires and retired to his deep, dark caverns, leaving his awful forge surrounded with smouldering masses of scoria and slag. At the time of my visit in August, the great dome was so elevated as almost to overtop the lower parts of the outer walls of Kilauea and look out upon the surrounding country. No important changes were noticed in the crater from this time until the spring of 1849. In April and May of this year, travellers upon the borders of Kilauea were startled by explosions and detonations from cones on the great dome. A party lodging in the hut on the upper banks were greatly terrified during one whole night, by hissings, bellowings, and sharp and loud detonations, sometimes like the discharge of whole ranks of musketeers, sometimes like field artillery, and sometimes like awful deep toned thunder, roaring, and reverberating around the adamantine walls of the dark cavern. These bellowings were repeated hourly through the night, and were attended by a brilliant column of red-hot lava thrown perpendicularly from an orifice in the apex of the dome, to the height of some fifty or sixty feet. At other times red-hot stones were projected with great force into the air and sent whizzing like fiery meteors through the gloom of night. As the glow of this scene a little abated, a stream of burning lava was disgorged from the orifice of a lateral cone on the ridge of the dome, flaming down to its base and winding along upon the dark substratum like a fiery serpent. Fire was seen through some of the fissures in the dome, and nearly the whole bottom of Kilauea was quivering and crackling with heat; so much so, that travellers feared to descend into any part of the crater.

These reports I have from those who professed to have been eye and ear witneses of the thrilling scenes. Since the time just mentioned no remarkable phenomena have been noticed in the crater. It has been for the most part in a quiescent state, with more or less steam and smoke, and occasionally opening a small red eyelid, or letting loose a few fire flies upon the wings of the night.

During December of 1850 the smoke and steam are said to have much increased; and the occasional throe of an earthquake indicates that all subterranean action has not ceased. Kilauea is evidently assuming more of the manners and habits of the fiery sisterhood. Her exhibitions are becoming periodical, arbitrary, capricious. With the exception that her throne is not a mountain summit, she more and more resembles Etna, Vesuvius and the Andean and Asiatic furnaces.

The sulphur beds remain much as formerly, except, perhaps, that the bank within the crater has less heat and activity, and the one above, or near the hut has a little increase of heat. Most of the sulphur is now obtained at the beds near the hut.

The eruption of 1840 is still hot and steaming at many points along its course, and hundreds of steam holes are still smoking in Puna and parts of Kau.

There is now one cone feebly active at a little distance from the dome in the crater. Those *on* the dome are now inactive.

The eruption in Mokuaweoweo, or the great crater on the summit of Mauna Loa, was first noticed in May, 1849, some little time *after* the extraordinary activity of Kilauea. This eruption never overflowed the crater in which it occurred, but spent all its force within the bowels of that deep chaldron. For two or three weeks it shot up a tall, beautiful and brilliant column of light perpendicularly and to a great height; this column, like that which led Moses and the hosts of Israel, being "a pillar of cloud by day and a pillar of fire by night." At the end of two or three weeks it faded away and disappeared.

The eruption on Mauna Loa immediately succeeded the action in Kilauea. I cannot say they were coincident; though they *may* have been, as the mountain is, as you are aware, often obscured in clouds. Whether or not there were any connection between the two eruptions we cannot determine.

Note by J. D. Dana.—If there was actually a connection in the instance above alluded to, the trifling effects observed may well excite our surprise: for how could so slight agitations be all the result, when the lava stands in Mauna Loa to a height of 10,000 feet above the great open pit of Kilauea on its slopes—10,000 feet higher in one leg of the syphon than in the other,—the crater too at the summit being in eruption at the time? See this Journal, x, 244, 1850, and Proc. Amer. Assoc., Cambridge, 1849, p. 95.

Art. XIII.—*On the causes of the disengagement of Electricity in Plants, and upon Vegeto-terrestrial Currents;* by M. Becquerel.*

Since the discoveries of Galvani and Volta, the researches on the development of electricity have taken a philosophical direction. It has been the object to discover not only the causes of its disengagement, but also the relations existing between electricity, molecular attraction and chemical affinity. The study of electro-physiological phenomena has also been pursued; and although to a less extent than other departments of this subject, the labors of Nobili, Marianini, Matteucci, du Bois-Reymond and others, show that general physics and physiology may alike profit by researches upon the presence of electricity in the operations of organic life and in the constitution of organized bodies.

The causes of the development of electricity in organized bodies, living or but a short time deprived of life, are physical, chemical and perhaps organic; and in the last case, they pertain to certain vital functions not yet clearly defined.

My object in this memoir is to exhibit the proper mode of investigating the physical and chemical laws operating in the production of electro-physiological phenomena, and also to give the results at which I have arrived in my researches on plants, whose simplicity of structure renders experiment more easy than with animals.

Some preliminary explanations are necessary to render the subject intelligible.

Organized bodies of the animal kingdom consist of osseous, tendinous, membranous, fleshy, &c. parts filled or moistened with liquids which render them more or less perfect conductors of electricity; and those of the vegetable kingdom, of woody fibre, vessels, &c., in which liquids are present with the same result. As the solids alone have no conducting power, the liquids act the principal part in the production of the electric effects observed, although vital action may intervene in some cases. These liquids, when two are in contact, necessarily produce through the resultant reactions sensible electric effects; observable not only with the condenser, by putting one of these liquids in relation with the earth and the other with one of the plates, but also with the multiplier by closing the circuit with two plates of platinum plunged in these liquids.

There may also be chemical reactions and currents without using the plates of platinum, when the solids and liquids are arranged as will be soon explained.

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* Ann. de Chim. et de Phys., xxxi, 40, 1851.

In aiming to ascertain the chemical origin of the currents produced in the interior of an organized body, it should be remembered that if two different liquids, separated by a permeable membrane are put in communication by means of two plates of platinum in connection with a multiplier, the magnetic needle deviates in a direction which indicates that the liquid acting as the acid sets free positive electricity, and that acting as alkali, negative electricity. The intervention of metallic plates is here indispensable to the production of electric currents; but it is unnecessary when certain solid substances, non-conducting and permeable, and liquid conductors, are arranged as follows, as already explained to the Academy.*

If solutions of potash and nitric acid separated by a thin layer of clay are put in communication by means of two plates of platinum, the acid liberates positive electricity as I have just said. If we substitute for the plate a tube having the form of a U, one decimeter in length, filled with moistened clay free from lime, and so prepared that the part which is plunged into the acid should be less and less acid, and that in the alkali less and less alkaline, in order that there may be but a simple chemical reaction, we have then an apparatus by the aid of which, on breaking the tube so as to have two conductors, decompositions may be produced.

Similar arrangements to this are found beyond doubt within organized bodies consisting of solid parts more or less permeable, and liquids which mingle only with difficulty under the operation of life, on account of the tissues.

When public attention was first called to the admirable discoveries of Volta, Dr. Baccomio of Milan† endeavored to construct piles of organic substances of vegetable origin, as Matteucci has for some years done with portions of animal muscle; but no true effects of the action of a pile were obtained. And how did Dr. Baccomio operate? He made a pile out of disks of the root of the beet, five to six centimeters in diameter and disks of walnut of like size, with which he caused a frog to contract, using as an excitor the leaves of Cochlearia. As there was nothing to prove that a similar effect would not have resulted from a single pair, there is no evidence for believing that the whole acted as a pile, especially if we consider the following facts.

M. Donné has obtained currents from animals and vegetables by putting in communication, by means of metallic plates or wires connected with a multiplier, liquids of *different* composition belonging to one and the same body and capable of acting chemically on the surrounding liquids. Having placed a plate of platinum in the mouth which is commonly alkaline, and

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* Comptes Rendus, xxiv, 505.

† Ann. de Chim. [2], lxii, 212.

the other upon the skin which secretes an acid, the needle deviated fifteen to twenty or even thirty degrees,—the mucus of the mouth on account of its alkaline nature giving the negative current. M. Donné obtained similar effects by experimenting on the stomach and liver, one secreting an acid and the other an alkali. Analogous effects take place with fruits; on inserting a needle of platinum into the stem end of the fruit and another into the opposite, there is an electric current; in apples and pears the current is from the flower-end to the stem-end, and in peaches, apricots and prunes, the reverse. If the needles are inserted at opposite points, 90° from the ends, (that is in the equatorial plane,) there is no current. The effects obtained were evidently due to the different composition of the liquids. On cutting a prune in two equatorially, and then obtaining the juice from each, and making with it a circuit, the currents were obtained as before, and in the same direction. The cause in such cases is evidently chemical.

Similar results are obtained when experimenting in organized bodies with two metallic conductors, if they are put in contact with two different liquids separated by tissues or permeable membranes. A frog prepared as by Galvani may be used in place of metallic conductors; its contractions indicate the electric effects that are produced immediately when the circuit is formed.

May the effects here manifested take place without the intervention of metallic conductors or the frog? To this, I shall reply soon. I mention here, that whenever two liquids react chemically upon one another, if these liquids do not form part in a closed circuit, there is an immediate recomposition of the two electricities disengaged at the point of contact; but if one of the two liquids is put in communication with the earth, or loses by evaporation the electricity which it possesses, the electricity of the other liquid may be collected with the conductor. Such are the data for studying the questions under consideration in this memoir.

I. *Electric effects produced by the Circulation of Sap.*

In plants, there is an ascending sap and also a cortical sap, the latter differing in composition from the former, and having, according to some physiologists, a descending movement. They are separated by tissues and produce effects like those above mentioned. These effects are the more remarkable from their relation to the composition of the bark and wood. To interpret them, it is necessary briefly to recall what is known upon the nature and distribution of these two varieties of sap.

The stem of a ligneous dicotyledonous plant is formed of two distinct parts, the bark, and the wood properly so called, separated by a liquid substance considered by many physiologists a semi-fluid tissue, called *cambium*, which is the principal element of

vegetable organization. The bark consists independently of the parenchyma, of epidermis, laticiferous vessels and cortical fibres. The wood is formed of medullary rays, of woody fibre, and pith. The bark like the wood contains a cellular and a fibrous part but in inverse position. The parenchyma which is analogous to the pith occupies the exterior of the bark, whilst the pith is at the centre. This inverse position corresponds, as will be seen, to inverse electric effects.

As each stem or branch is composed of an uninterrupted series of concentric heterogeneous layers, their successive contacts ought to give rise to electric currents proceeding from the unlike character of the liquids moistening these layers. These effects are rendered sensible—1, by the aid of platinum needles introduced into two contiguous or more or less distant layers, reacting upon the neighboring layers; 2, by collecting with a condenser the electricity carried off from the plant by the vapor of water exhaled by the leaves and by the oxygen proceeding from the decomposition of carbonic acid under solar influence; 3, by using platinum needles in order to ascertain the simultaneous electric states of the plant and the earth.

The moisture of the earth enters the roots by their extremity through endosmosis and capillarity, passes into the cellules situated above, and reaches the stem where the ascending movement is continued: it dissolves some portions of substances in its course, increases in density, and constitutes then what is called sap. The ascent of the sap is due not only to endosmosis and capillarity, but also to the buds which by their growth draw up the stem and branches the material necessary for their development. The buds form leaves, which by affording evaporation, aid in the production of the ascending movement and are a means consequently of manifesting electric effects.

We know not with exactness the different organs passed through by the sap in its evolution. We can say only that in spring it fills the cellules, the fibres, vessels, &c., and occupies almost entirely the woody substance. The ascending sap, reaching the young branches, passes to the surface of the bark in the parenchyma as well as to the leaves; and when once spread in the green part, it is in direct connection with the atmospheric air, separated from it only by a thin membrane through which respiration is going on. The sap, which is thus intimately modified, becomes less aqueous through evaporation of a part of its water. Carbonic acid gas is decomposed, carbon is assimilated and oxygen exhaled. The color of the leaves and young bark shows that considerable changes are going on in the sap. Does this sap, newly elaborated, redescend through the bark, depositing along its passage material for the formation of tissues? Some physiologists still doubt on this point. But the experiments of

Biot tend to prove the circular movement of the sap. On examining the optical properties of the ascending and parenchymatous sap of the maple, he observed that the first caused the plane of polarization to turn to the right and the second to the left, whilst the two saps of the birch acted the reverse. These experiments which according to Biot establish a reciprocal dependence between the two saps, are supposed to demonstrate their circulating movement. It is certain at least that the parenchymatous sap differs from the ascending sap.

The anatomical and physiological details just given were required for interpreting certain electrical effects produced in the different phases of the movement of the sap, effects of interest to meteorology as well as to vegetable physiology.

The following are the experiments. Suppose now a stem of a young poplar (when in sap) has been laid open by a transverse section, so as to show distinctly all the concentric layers of which it consists. If the extremities of two platinum needles without polarity, covered or not with a layer of distilled water and in connection with a multiplier, be introduced simultaneously, the one in the pith and the other in one of the layers of the wood or cortical system, the needle deviates 5, 10, 15 degrees or even more, according to the sensibility of the apparatus, the sappy state of the plant, and the nature of the envelop in which the second needle is placed. The direction of the deviation, which is invariable, indicates that the pith furnishes positive electricity to the needle in contact with it, and the outer envelop negative electricity to the other needle; there is then a current from the exterior to the interior.

The magnetic needle after some oscillations takes an equilibrium which is not fixed, the deviation diminishing by degrees without ever reaching zero. This diminution in the intensity of the current is due to the polarity acquired by the platinum needles, which produces a current inverse to the former and destroys its action. The primitive current is the more intense, other things equal, the nearer the insertion of the outer needle is to the epidermis and consequently to the green part of the parenchyma.

On drawing out the first needle from the pith, and inserting it at different points, approximating towards the surface, the currents are similar in direction but of diminishing intensity; and this goes on until the needle is placed in the *cambium* between the wood and the bark, when the current changes in direction and becomes more intense.

On raising a piece of bark, from which the epidermis is easily removed, and applying a plate of platinum to each surface, both being connected with a multiplier, effects of great intensity are obtained. With the bark of alder in full sap, the deviations are

sometimes 90 degrees, and the needle may even whirl round. It is hence evident that *the bark forms a voltaic couple*, the outer surface or parenchyma being the positive side and the inner covered with the cambium the negative. The action soon ceases when the bark is removed from the branch. This is shown by taking a piece of the bark of a young branch of alder, removing the epidermis and putting it between two plates of platinum and the whole under a pressure of 2 kilograms between two pieces of wood; a current is immediately produced; but on repeating the trials at short intervals, being careful to depolarize the platinum plates each time, the effects diminish rapidly, although the surfaces may be moistened with distilled water,—and sometimes they are not sensible after half an hour. These electric properties diminish much more rapidly than in the muscles of cold-blooded animals in which they remain several hours after death.

When the bark is not separated from the branch, these properties continue for several days, proving that their disappearance should be attributed to chemical changes which take place in the sap through contact with the air.

The bark is in reality, therefore, a voltaic couple, which loses rapidly its electric property when detached from the wood and left exposed to the air. It follows, that in the reaction upon the sap of the layer of air that adheres to the surface of the platinum, there ought to be somewhat analogous effects, as regards intensity, to those which take place by contact with the atmosphere. The layer of hygrometric moisture adhering to the surface of the platinum has no influence, since the effects are the same if the needles have been previously heated to redness.

In recapitulation,—we see, that from the pith to the cambium, the ligneous layers are less and less positive with reference to the pith, while from the cambium to the epidermis, the cortical beds and parenchyma are more and more positive, or at least comport themselves thus. In the production of the derived currents, this inversion in the electric effects corresponds with the position of the cellular tissue in the bark and in the wood; in the bark it is external, in the wood internal, and in each case it is positive.

Where then, do the electric properties of the bark reside? Is it in the different layers which compose the cortical system, or only in the epidermis and cambium? The following experiments, if not completely settling this question, tend to its elucidation.

If we take a branch of alder in full sap, and make a transverse section, then insert one of the needles between the bark and the wood and the other into the parenchyma after removing the epidermis, the needle deviates a certain number of degrees, say 20°. If we now withdraw the second needle which was placed in the periphery, remove the green layer with an ivory knife

and put the needle in place again upon the denuded surface, there is sensibly the same deviation. If another layer be removed, there is still by a similar trial a deviation in the same direction but a little less strong, or about 15 degrees. On continuing the removal of the layers and making successive trials, the electric effects take place in the same direction and do not cease until only the cambium is left. All the parenchyma cortical layers thus have a like effect; and does it therefore follow that the layers united form a voltaic pile? Certainly not: the experiments thus far made do not authorize this conclusion.

However it may be, the cause which makes the bark a voltaic couple and perhaps a pile, by the juxtaposition of the concentric heterogeneous beds of which it consists, appears to be purely chemical. In fact, the ligneous system is penetrated by the ascending sap rich in oxygen, while the liquid in the cortical tissue, on traversing the green parts, is continually losing a portion of this element by contact with the air. These two saps, by reacting upon one another, through the medium of the intervening tissues, necessarily cause electric effects; the ascending sap, which is most oxygenated should act as an acid with regard to the other, and develop positive electricity, while the descending sap should disengage negative electricity. The inversion in the bark and wood depending on the position of the cellular tissue, is to be attributed to the nature of the liquids they contain.

The electricities disengaged when one of the needles is inserted in the pith and the other in the parenchyma, have, I repeat it, a chemical origin; for if the needles are withdrawn and while still covered with the sap are put into distilled water, the same effects nearly, as to intensity, are obtained, effects which can be attributed only to the reaction, upon the water, of the sap adhering to the surface of the needles.

In these experiments, for inserting the needles into the stem, especially the woody part, I make small holes with a steel awl covered with a thick layer of gold, so that no trace of oxydizable metal can be introduced to occasion secondary electric effects.

In herbaceous plants, like Cacti, Euphorbiæ, &c., consisting almost wholly of parenchyma, it is difficult to detect the electric effects which are so distinct with stems provided with bark.

As bearing upon this subject, I mention the following experiments which will show the rapidity with which the air reacts upon the sap in the green parts and modifies its composition.

The ascending sap being more oxygenated than the parenchyma sap, called the descending, ought to give out, by its action upon the latter, positive electricity as before observed. If we insert transversely under the epidermis, into the parenchyma, the two platinum needles, one centimetre apart, there will be no

effect, if the insertion of the two needles is simultaneous and they are not polar. But on withdrawing one needle and inserting it again in the same place, there is at once a current causing a deviation of 40 degrees, and the direction shows that the needle restored gives negative electricity. On removing and replacing the other one, the effect is reverse, and this one now gives negative electricity. This succeeds well if the wood is in sap and has been separated but a short time from the trunk.

In this case, the effect is similar to certain facts mentioned in my earlier work on electro-chemistry. When two plates of platinum in connection with a multiplier, are put into a solution, recently prepared, of protonitrate of iron, on withdrawing one of the needles and inserting it again some minutes after, there is a current whose direction shows that the plate replaced gives positive electricity. This effect proceeds simply from the fact that the solution of the protonitrate, and the part of this solution which is on the platinum plate while exposed to the air, are not alike in composition: the portion adhering to the plate has passed, during the exposure to the air, to a higher state of oxydation, and comports therefore like an acid with reference to the solution in the vessel. The steps in the process are easily explained. When nitric acid reacts on iron, deutoxyd of nitrogen and nitrous gas are disengaged, and protonitrate and some deutonitrate of iron are formed; when the solution is exposed to the air, the deutoxyd becomes nitrous acid and the protonitrate deutonitrate. These transformations which take place slowly in the mass of the solution, are effected very promptly in the layer that adheres to the surface of the platinum. On becoming rapidly saturated with oxygen, the solution reacts upon the solution in the vessel and produces electric effects like those from the action of an acid on an alkali, or from two substances reacting as such. The recently prepared protonitrate is required for these vessels, because of the change to deutonitrate which takes place in the protonitrate after a while on exposure.

If in the experiment with the sap the effects are the reverse of those with the protonitrate, it is owing to this;—that the sap of the parenchyma loses oxygen on exposure instead of gaining it.

These facts demonstrate that a very slight difference of chemical composition in two liquids of a plant, separated by a permeable membrane, is sufficient to afford electric effects in the manner explained, and these effects vary with changes experienced through the surrounding air or medium.

These effects should therefore be taken into consideration in experimenting upon the causes which produce electric currents in organized bodies, when one of the liquids is momentarily in contact with the air.

The electric effects produced between the sap of leaves and the same sap exposed a moment to contact with the air, may be shown by piling up thirty leaves or so and compressing them strongly, then inserting two needles, one on each side; on taking out one and again restoring it to its place after some instants, it gives negative electricity. This is due to the change in the sap of the parenchyma on the needle that had been exposed.

The intensity of the current depends on the quantity and the composition of the liquid in the leaves. Those of ivy produce a deviation of twenty to thirty degrees; those of the poplar of Italy a little less or more strong, according as old or young leaves are used. Complex effects sometimes result from modifications more or less profound which the sap undergoes in contact with the air, and from the facility with which the sap, on the exposed needle, mixes with the surrounding medium, gaseous or liquid.

It is possible therefore to compare leaves of different kinds in this respect, such as elder and walnut. Twenty leaves of each kind, in two piles, are put in contact by one of their surfaces and compressed. A needle of platinum is inserted in each surface; one of these needles is withdrawn and after some instants replaced. The direction of the deviation shows that the replaced needle gives negative electricity. The amplitude of the deviation depends on the nature of the leaf, as the following results from the walnut and elder show.

The needle removed and again replaced in the elder gave for deviation, on the first impulsion, for three trials, 13°, 13°, 11°, and for three alternate trials with the walnut, 24°, 22°, 24°.

These results show that the sap of the walnut undergoes a more rapid change by contact with the air than that of the elder, the current being nearly double in intensity.

Leaves of poplar combined with those of walnut give results still more marked. The leaves of poplar with regard to those of ivy, afford the relation of thirty to twenty.

We can draw no conclusion from these results whilst we are ignorant of the chemical composition of the different saps: we only know that all do not undergo the same alteration in equal times. Such piles, made of series of leaves of different species, may yet serve to educe facts of importance illustrating some points in vegetable physiology. If two such series of leaves are put in contact, and, before pressure, a plate of platinum connected with a multiplier is applied to each free face, we obtain the following results, with walnut, elder, linden, and orange, arranged in couples:—

		Kind of electricity.	Angle of deviation.
1.	Leaves of walnut, . .	—	35°
	" elder, . .	+	
2.	Leaves of linden, . .	+	20°
	" walnut, . .	—	

		Kind of electricity.	Angle of deviation.
3.	Leaves of linden, . . .	+	30°
	" elder, . . .	—	
4.	Leaves of orange, . . .	+	10°
	" linden, . . .	—	
5.	Leaves of orange, . . .	+	50°
	" walnut, . . .	—	

In the preceding pages I have treated of the effects obtained with a transverse section of a stem; it remains to speak of the electric effects observed in a longitudinal section. Let *a* and *b* be two points in the green part of the parenchyma of a stem at different distances from the ground and several decimeters apart, *a* being the upper and *b* the lower. On introducing transversely into the parenchyma at each of these points one of the platinum needles, there is immediately apparent an electric current, the direction of which evinces that the needle at *b* gives negative electricity, and that at *a* positive. Hence the parenchyma sap at points thus distant has not the same composition: at the lower point *b*, as it contains less oxygen than at *a*, since it loses more and more oxygen in passing along the green part of the parenchyma, it ought to disengage negative electricity.

A current is also obtained on establishing a connection between the cambium and the leaves, which may be effected, by placing one needle between the bark and the wood, and the other in a mass of superimposed leaves all being a part of the plant. On closing the circuit, a current at once appears going from the interior to the exterior, as in the case when the needle which is here in the leaves is placed in the parenchyma while the other is in the cambium; the result corresponds to the nature of the sap which circulates in the leaves and parenchyma. We give beyond, the consequences from the facts that have been presented.

II. *On the Electric state of the earth relatively to that of Plants.*

As the earth is in direct and permanent communication with plants by means of the roots, it ought to participate in the electric state resulting from the different elaborations taking place in their tissues. This question bears upon the electric state of the atmosphere, and nothing should be omitted which can serve to elucidate it.

It is known that the earth is in a constant state of negative electricity, whilst the air, when calm and without clouds, contains an excess of positive electricity whose intensity goes on increasing as we ascend above the surface of the earth. The earth and atmosphere are therefore ordinarily in two contrary electric states. These states change during storms or when clouds appear; for

these are sometimes positive, and sometimes negative. What are the causes which operate in the production of the electric effects of the earth and atmosphere? We cannot give a reply wholly satisfactory to this question, although we know that chemical changes going on upon the earth's surface must be powerful causes.

De Saussure and several other physicists have endeavored to find evidence of the disengagement of electricity during the evaporation of water. But as they have not taken into account the alteration which the vessels experience in the process, the results were evidently unsatisfactory. M. Pouillet undertook the experiments anew, endeavoring to get rid of the causes which complicate the problem. He sought to prove that evaporation and chemical action in vegetables were the two great sources of atmospheric electricity. I will mention his results, that they may be compared with the facts presented in this memoir.

If a little water is thrown into a platinum crucible heated to a white heat it takes the spheroidal state and evaporates slowly, and on cooling to a certain temperature suddenly passes to a state of vapor. By means of the condenser no disturbance of electric forces was perceived, either during the slow evaporation, or the rapid dispersion of the water.

With acetic acid, sulphuric acid, very pure nitric acid, in place of water, there was no disengagement of electricity perceived; but the result was different when the water held in solution a salt or some substance that is a conductor of electricity. According to M. Pouillet, electricity was produced with a solution of strontian during slow evaporation; and when the water was put in vibration, the amount was quite considerable. The vessel became positively electric and the vapor negative. Hence, at the instant when a separation takes place between the molecules of water and those of strontian, electricity is given out; the strontian retains the positive, whilst the water on evaporating carries with it the negative. The earths and alkalies act in the same manner as strontian.

On experimenting with water containing ammonia, there was an abundant discharge of electricity, but with reverse electric products; the vessel becomes negative, and the water which vaporizes with the ammonia positive,—indicating that the latter, in passing off, carries with it an excess of positive electricity.

If the water holds in solution 1–100 of sulphuric acid or even less, there is a discharge of electricity and the vessel is negative.

With saline solutions, electricity was equally given out; the vessel was always negative whether the salts were neutral, subsalts, or acid. The vapor of water was constantly positive.

I should here state that several physicists who have repeated the experiments of M. Pouillet with saline solutions, a solution

of common salt for example, have obtained distinct effects (operating by throwing some drops of the solution on a plate of platinum raised to a white heat,) only at the instant when decrepitation began, an effect announcing the volatilization of the last portion of the water.

As to the electric effects produced in vegetation, M. Pouillet experimented as follows. Having placed upon a varnished wooden table twelve glass capsules covered with varnish and forming two ranges, he filled them with earth and connected them together by means of platinum wire passing it from the interior of one to the interior of another, and so on; he then put the system in communication with the superior plate of a condenser whilst the inferior plate was in connection with the soil. Different grains were successively sown in the earth of the capsules. During the first two days the grains swelled and the germs came out of the envelop. The condenser gave no signs of electricity. When the germs had risen above the soil, on separating the two plates of the condenser, the two strips of gold-leaf diverged, and evinced negative electricity. M. Pouillet thence concluded that during the action of the oxygen of the air on the amylaceous substance of the cotyledons, the gases which are disengaged carry with them some positive electricity, and leave in the young plant and consequently in the earth an excess of negative electricity. Some hours were required to charge anew the condenser. During the night and morning, the same results were obtained, showing that light had no influence, which is natural since light does not intervene in the first acts of vegetable life. The experiments were made with wheat, grains of garden cress, and gillyflower, and the same results were obtained for ten or twelve days.

M. Pouillet has also observed that when the growth of a plant has been in progress three or four days, the condenser is charged if by connection for a second only;—an effect due, according to him to this, that the earth of the capsules becomes on drying, an imperfect conductor and so retains for some instants a portion of disengaged electricity which serves to charge the condenser at intervals.

In all probability, the effect observed by M. Pouillet should be attributed to the action of the oxygen of the air upon the carbon of the amylaceous material of the grain, which is thereby changed into sugar destined for the nutriment of the embryo during the first periods of growth.

The electric effects observed by M. Pouillet, in this first period, accord with the ordinary electrical states of the earth and atmosphere: but are they produced also in the subsequent stages of vegetation? I think not, judging from facts to which I shall soon refer.

The different electrical states of the earth and air have been attributed also to the gradual decrease of terrestrial heat from the lower parts of the solid crust, even to the highest limits of the atmosphere. I have been the first to bring forward this opinion; but as yet there is no fact that proves it.

I proceed now to the concomitant electric effects obtained from the earth and plants, after the plant is grown, or has made considerable progress towards maturity. Operating with platinum needles or pointed plates, as before, if one of the needles is inserted into the parenchyma of a stem or any branch of a plant and the other in moist soil at some distance from the root (several yards for example), there will always be a current, showing that the earth contains an excess of positive electricity and the parenchyma an excess of negative. The deviation varies with the humidity of the soil and the sappy state of the plant, but may be 15, 20, 30, 40 degrees, or even more.

The magnetic needle that deviates to 15 degrees, stops at 8 degrees after oscillating for a while; it still diminishes very slowly to 2 or 3 degrees, owing to the polarity acquired by the platinum; if this polarity is destroyed by moving the needle in the ground without withdrawing it, the deviation increases 2 degrees; while the same effect on the other needle restores the deviation to its first amount. This greater effect with the latter is owing to the fact that as the sap in contact with the needle is altering more or less rapidly, the current would have a new energy when the altered bed is disturbed by friction. There is little or no effect when one of the needles is in the wood or pith. But if inserted in a number of leaves, while still on the branches, the result is similar to that obtained from the parenchyma, proving a similar constitution for the sap of both.

The same effects are obtained from all plants, even the herbaceous. We may then receive as a principle, that in the act of vegetation, when germination is accomplished, the ascending sap, which communicates with the soil through the roots, carries up an excess of positive electricity, whilst the parenchyma sap furnishes to the air by aqueous evaporation an excess of negative electricity. Vegetation therefore acts the reverse of the causes which ordinarily render the air positive and earth negative. It is probable that the electric effects thus produced, as they are incessant, should exert, especially in tropical regions and wooded countries, considerable influence upon the electric state of the atmosphere which plays so important a part in the production of meteoric phenomena.

As the cambium, or the substance so designated, is negative compared with the wood and pith occupying the central part of the plant, the positive state of the parenchyma as related to the cambium, has only a secondary influence upon the effects

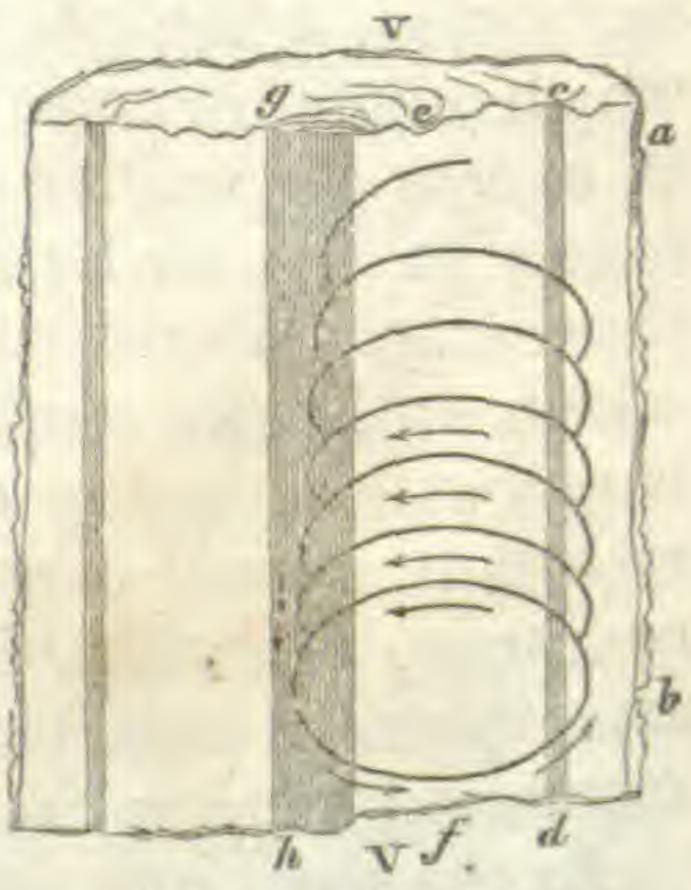
just mentioned, since the direction of the primitive current is not affected by it.

III. *Are there direct Electric Currents in Plants.*

May we conclude from the facts presented in the first part of this memoir that there are constant electric currents circulating in plants and also between them and the earth? This question is important to physiology, since such currents cannot circulate in liquids without producing chemical action: and it is of no less interest to the meteorologist. To reply to it, we must consider whether the two conditions necessary for the production of such currents are fulfilled.

The *first* undoubtedly exists, as there are present two different liquids reacting chemically upon one another through a medium of permeable tissues: and it is the same with the *second*, which requires the contact of two liquids by insensible transition. In fact, in a horizontal section of a stem of a plant, the immediate communication takes place readily through the tissues between the ascending sap and the parenchyma sap. In a longitudinal section, it is well known that the ascending sap, before it enters the plant by the roots, consists of water including some air, carbonic acid gas, and small quantities of saline and organic matters taken up from the soil. In its passage, it dissolves by degrees a portion of the substances met with along its course, acquires increased density, and constitutes then the *ascending sap*. The parenchyma sap, after elaboration in the leaves, loses a portion of its constituent parts in the process of nutrition. Each is in the condition necessary for mutual contact by insensible transition, and consequently for producing electric currents without the addition of metallic plates.

These currents ought to circulate as in the annexed figure. VV is a longitudinal section of a plant; *ab* the bark; *cd*, the cambium; *ef* the wood; *gh* the pith. Positive electricity entering at *h* and *f* through the roots, and ascending in the direction *ba*, produces, as appears from the facts, partial currents proceeding from the bark to the pith, and this even to the extreme branches.



We are not able to make other inductions from the facts thus far observed, nor point out the chemical action resulting from such currents in the tissues. New experiments are necessary before we can know what to believe on these points.

Recapitulation.—The observations presented in this memoir establish the following facts:

1. The production of derived currents in the stems of plants by the aid of platinum needles, inserted, one into the bark, the other into the wood, which currents have a direction from the parenchyma to the pith.

2. The production of similar currents in the bark proceeding from the cambium to the parenchyma, having an inverse direction as compared with the former.

3. The sap of the cortical parenchyma, held exposed to the air for some instants, undergoes such a modification that when put again in contact with the parenchyma sap, it becomes relatively negative.

4. The production of derived terrestrial currents, through the medium of the roots from the pith and other parts of the stem.

5. The direction of the terrestrial currents shows that in the act of vegetation, the earth takes constantly an excess of positive electricity, and the parenchyma of the bark and the leaves an excess of negative electricity which is transmitted to the air through the exhaled water.

6. The distribution of the ascending sap and the sap of the cortical parenchyma leads to the belief that there are currents circulating continually in plants, directed from the bark to the pith, passing by the roots and earth, and perhaps without passing by these two intermediaries.

7. Chemical reactions are the first cause, beyond doubt, of the electric effects observed in plants. These effects are very varied, and have thus far been observed only in a small number of cases.

8. The opposite electric states of plants and the earth give reason for concluding, that through the great extent of vegetation over the continents and islands, they exert a decided influence upon the electric phenomena of the atmosphere.

Art. XIV.—*On the Rings of Saturn;* By G. P. Bond, Assistant at the Observatory of Harvard University.*

The question of the multiple divisions of the ring of *Saturn* has engaged the attention of astronomers from an early period. Cassini appears to have been the first to notice the primary division, though he has placed it midway between the inner and the outer edges.

This interval is always visible with a good telescope, but much nearer to the outer edge than Cassini describes it to be. Short, next, with a telescope of twelve feet focus, probably a reflector,

* Cited from the Astronomical Journal, vol. ii, No. 1 and 2.

saw two or three divisions outside of the center of the ring; a figure is given in Lalande's Astronomy. In June, 1780, Sir W. Herschel noticed, on four different nights, a division near the inner edge. From its never, either previously or subsequently, having been seen by him, it is probable that the subdivisions are not permanent; otherwise they could scarcely have escaped detection under the scrutiny to which he subjected every thing appertaining to the system of *Saturn* for thirty or forty years. This inner division is figured and described in the *Philosophical Transactions* for 1792. In Gruithuisen's *Astron. Jahrbuch*, for 1840, pp. 103–105, mention is made of lines seen on both rings in 1813 and 1814. Quetelet, at Paris, with an achromatic of ten inches' aperture, saw the outer ring divided in December, 1823.

On the 17th of December, 1825, and on the 16th and 17th of January, 1826, at least three divisions were seen on the outer ring by Captain Kater. A full account, illustrated with engravings, has been published in vol. iv, Part II, of the Memoirs of the Royal Astronomical Society. This contains also a collection of the accounts of previous observers. Two reflectors of the Newtonian form were used, of between six and seven inches' aperture.

At Berlin, on the 25th of April, 1837, the outer ring was seen by Professor Encke, with perfect distinctness, divided into two nearly equal parts, and several divisions were recognized on the inner edge of the inner ring. The great equatorial of the Berlin Observatory was used with an achromatic eyepiece.

On the 28th of May, the place of the outer secondary interval was determined. The great optical capacity of the telescope, and the eminence of Professor Encke as an observer, give the highest value to these observations. They are found in the *Astr. Nachr.*, No. 338. No. 357 of the same volume has a notice of several divisions on both rings, seen by De Vico, at Rome, with the equatorial of the Roman College, the object-glass of six inches, by Cauchoix. A letter from M. Decuppis, *Comptes Rendus*, vol. vii, gives a description of several divisions seen at Rome, in May, June, and July, 1838.

On the 7th of September, 1843, a division of the outer ring was detected by Messrs. Lassel and Dawes, at Starfield. They employed a Newtonian reflector of nine inches' aperture; the details are to be found in vol. vi, of the Monthly Notices of the Royal Astronomical Society.

The newly discovered inner ring of *Saturn* cannot properly be classed with the subdivisions of the old ring, as it lies within its inner edge.

We have, then, the best assurance in the number and reputation of those who have described the phenomena in question,

that to set aside these appearances by referring them to some optical deception on the part of the observer, or to some defect in his instrument, is an explanation altogether insufficient and unsatisfactory. On the other hand, we know that some of the best telescopes in the world, in the hands of Struve, Bessel, Sir John Herschel, and others, have given no indication of more than one division, when the planet has appeared under the most perfect definition. The fact, also, that the divisions on both rings have not usually been visible together, and that the telescopes which have shown distinctly several intervals in the old ring have failed to reveal the new inner ring, while the latter is now seen, but not the former, may be taken as some evidence that the difference is not probably owing to any extraordinary tranquillity or purity of the atmosphere, nor to any peculiarly favorable condition of the eye or instrument, but rather to some real alterations in the disposition of the material of the rings.

Admitting this, the idea that they are in a fluid state, and within certain limits change their form and position in obedience to the laws of equilibrium of rotating bodies, naturally suggests itself. There are considerations to be drawn from the state of the forces acting on the rings which favor this hypothesis. For instance, on the assumption that the matter of which the ring is composed is in a solid state, we may compute for any point on its surface the sum of the attractions of the whole ring and of *Saturn*. The centrifugal force, generated by its rotation, may then be determined from the condition that the particle must remain on the surface. Now in the case of a solid ring, particles on the inner and outer edges must have the same period of rotation. This condition limits the breadth of the ring, for if it be found necessary for the inner and outer edges to have different times of rotation, this can be accomplished only by a division of the ring into two or more parts. In this way Laplace has inferred the necessity of there being several rings. From a more exact analysis, M. Plana, in the *Mem. Acad. Turin*, vol. xxiv, concludes that more than one ring is not essential. The data which he assumed we now know to have been very wide of the truth, as regards the mass and thickness of the ring.

Bessel's last determination of the mass derived from the progressive motion of the line of apsides of the satellite *Titan*, which amounts to a very sensible quantity, makes that assumed by Plana at least thirty times too large. If Bessel's mass be received, the necessity of numerous rings can scarcely be questioned.

If the density of the ring be the same with that of *Saturn*, and its matter uniformily distributed with Bessel's mass $= \frac{1}{1\,1\,8}$ of *Saturn's*, its thickness, seen from the earth, would only subtend an angle of $\frac{1}{2}\frac{1}{9}$ of a second of arc. It is a confirmation of the

mass adopted, that this does not vary more from that derived from observation, than we can attribute without improbability to a difference of density between the ring and *Saturn*. Sir John Herschel states, *Outlines of Astronomy*, p. 315, that it cannot be so large as one twentieth of a second. In the *Astronomical Journal* for January, 1850, I have given as the result of observations with the great refractor at Cambridge, during the disappearance of the ring in 1848–49, a thickness not exceeding one hundredth of a second. We cannot suppose the mass to be greater than that assigned by Bessel, without also admitting a density much greater than that of *Saturn*, the smallest observed thickness already requiring a density more than three times that of the planet.

In the calculations which follow, I have supposed the mass of the ring not greatly to exceed $\frac{1}{11\frac{1}{8}}$ of *Saturn*, and its thickness $\frac{1}{45}$th of a second. For the other elements I have used Struve's measurements.

The analysis of the attraction of the ring presents great difficulties. Laplace has taken as an approximation for a very narrow ring the attraction of a cylinder of infinite length, having for its base an ellipse. Plana takes account of the curvature by assuming the breadth to be very small compared with its radius. But if more than the first term is taken into account, the numerical calculations become very complicated. These difficulties may in part be avoided by taking account of the form of the surface only in the immediate neighborhood of the point attracted. In all the parts distant compared with the thickness, it is sufficient to suppose the whole mass collected in the plane of the center of the rings. This plane, considered as made up of parallel straight lines, attracts the particle by the sum of the attractions of its elements. The attraction of each line parallel to its length, y being its perpendicular distance from the radius joining the attracted particle with the center, and r and r' the distances of its extremities from the same point, will be $\left(\frac{1}{r}-\frac{1}{r'}\right)dy$.

From which the attraction of a plane surface is easily computed by quadratures. For the ring on the surface of which the attracted particle is, and for the two next adjacent, I have used Laplace's formula, *Mécanique Céleste*, vol. ii, [2092]. This assumes the figure of the surface to be elliptical; in the absence of any certain knowledge of its form, this has the recommendation of simplicity and of satisfying also the conditions of equilibrium. The hypothesis of any other figure would not materially affect the conclusions arrived at, provided the mass and density be not altered. The numbers thus obtained are only approximations to the truth, but are sufficient for the object in view.

If we adopt for unity the radius of the outer edge of the outer ring, we have from observation the thickness of the ring $=2b<\frac{1}{9}\frac{1}{0}\frac{1}{0}$. Let r and r' be the radii of the inner and outer edges, and i the interval between two adjacent rings,

$$r_0=\frac{r+r'}{2},\ 2a=r'-r.$$

Any intervals permanently existing so large as one half, or even one third, of that usually seen, could not escape observation. Moreover, if the subdivisions are numerous, the width of the intervals must be proportionally diminished, because the whole area occupied by them goes to diminish the amount of light reflected, and to increase the density of each ring, both of which are already large. The light of the ring being sensibly brighter than that from an equal area on the ball, it is not probable that any considerable part of the light of the sun is transmitted through intervals. And to preserve the same mass, if the intervals are large, the matter must be compressed, as it is not allowable to give a thickness greater than is indicated by observation. To avoid the hypothesis of a reflective power, and a density greater than we are warranted in assuming, we must, therefore, consider the intervals to be very narrow. We may take, then, the width of all but the known interval as certainly less than 0·01, which is one half of the width of the known interval. From the blackness of the shadow of the ring upon the ball, which would be diminished in intensity were a considerable part of the sun's rays transmitted, we may infer that the intervals which reflect no light at all cannot occupy an area so large as one fourth of the average breadth of the rings; that is, $r'-r>0{\cdot}04$.

The above are very liberal allowances, but it is important to assume the intervals as large as possible, so as to diminish the chances of a collision, which at best is almost inevitable.

We come now to consider the forces acting on the rings.

If f' be the force with which a particle at the outer extremity of the major axis of a ring is attracted to its surface by the sum of the attractions of all the rings, f the same force for the inner edge, s the mass of *Saturn*, and t the time of revolution of any ring in days, the centrifugal force at the distance r will be $=\frac{kr}{t^2}$, log. $k=9{\cdot}1207$.

Then, in order that the particle should remain on the surface, we must have

$$f>\frac{s}{r^2}-\frac{k}{t^2}r;\ f'>\frac{kr'}{t^2}-\frac{s}{r'^2}.$$

Therefore,

$$r'-r<\frac{r_0^{\,3}}{3s}(f+f').$$

If we put $F=\frac{s}{r_0^2}=$ the attraction of *Saturn* on the middle of any ring, we obtain the relation,

$$\frac{f+f'}{F}>3\frac{r'-r}{r_0}.$$

From the smallness of the mass of the ring, as well as from its unfavorable distribution, it is easy to see that $r'-r$ must be very small compared with r_0.

To obtain f and f', I have computed from Laplace's formula the following values: f_0 is the attraction of a single ring upon a particle on its surface, at the extremity of the major axis of its base; f_1 and f_2 the attractions of the two next adjacent. The interval between $=0{\cdot}01$, $2b=\frac{1}{900}$. The radius of the outer edge of the outer ring being $=1$.

Attractions of Three Narrow Rings.

	f_0	$\frac{f_1}{f_0}$	$\frac{f_2}{f_0}$
$a=0{\cdot}01$	$+0{\cdot}00661$	$-0{\cdot}284$	$+0{\cdot}134$
·02	679	·393	·150
·03	685	·460	·154
·04	689	·507	·157
·05	691	·543	·160
·06	692	·571	·162
·07	693	·594	·164
·08	693	·614	·165
·09	694	·631	·166
·10	$+0{\cdot}00694$	$-0{\cdot}646$	$+0{\cdot}166$

The attraction of the whole ring, considering its mass to be uniformly distributed, I have next computed by quadratures. Breadth of whole ring $=0{\cdot}335$. Radius of outer edge $=1$.

Distance of particle within the outer edge				$=0{\cdot}0075$	Attraction	$=+4{\cdot}52\times$ mass of ring.
"	"	"	"	·0475	"	2·42
"	"	"	"	·0875	"	1·70
"	"	"	"	·1275	"	1·16
"	"	"	"	·1675	"	0·61
"	"	"	"	·2075	"	$+0{\cdot}04$
"	"	"	"	·2475	"	$-0{\cdot}52$
"	"	"	"	·2875	"	1·32
"	"	"	"	·3275	"	$-3{\cdot}53$

These two tables give the means of finding f and f' with sufficient exactness. For *Saturn* we have

$S=\frac{4}{3}\pi\left(\frac{17''{\cdot}7}{40''{\cdot}095}\right)^3$; log. $S=9{\cdot}5567$; log. mass of ring $=7{\cdot}4848$.

The density of the ring is assumed $=$ *Saturn's*, unless it be otherwise stated. A change in the density affects only that part of the ring's attraction depending on f_0, f_1, and f_2.

But $f+f'$ will be changed very nearly in the direct ratio of the different densities when the rings are narrow.

We will first suppose the case of but one ring without division.

$r=0{\cdot}665$ $\qquad$ $r'=1{\cdot}000$

$r_0=0{\cdot}8325$ $\qquad$ $r'-r=0{\cdot}335$

Upon a particle at a distance within the outer edge $=0{\cdot}21$, the attraction of the whole ring becomes $=0$. This gives for the time of rotation $t=0{\cdot}43$. The excess of *Saturn's* attraction over the centrifugal force at the inner edge $=0{\cdot}37$. At the outer edge the centrifugal force is in excess by 0·33. We must therefore have,—

$f>0{\cdot}37$ $\qquad$ and $f'>0{\cdot}33$

But $f=0{\cdot}0040$ $\qquad$ and $f'=0{\cdot}0070$

Assumed value of $r'-r=0{\cdot}335$

Required " $<0{\cdot}0058$

If there be but one ring, it will be necessary to increase its attractive force by sixty times its probable value, in order to retain its particles on its surface.

With a single division into two equal rings, we have for the inner of the two, giving such a time of rotation as will retain particles on the middle from leaving their place,

$t=0{\cdot}39$ $\qquad$ $r=0{\cdot}665$ $\qquad$ $f>0{\cdot}25$ $\qquad$ $f'>0{\cdot}19$

$r'=0{\cdot}8325$ $\qquad$ $f=0{\cdot}0050$ $\qquad$ $f'=0{\cdot}0042$

$r'-r=0{\cdot}1675$ $\qquad$ $r'-r$ computed $=0{\cdot}0036$

For the outer ring,

$f=0{\cdot}0012$ $\qquad$ $f'=0{\cdot}0081$

$r'-r<0{\cdot}0066$ computed.

$r'-r=0{\cdot}1675$ assumed.

As no change of mass or density within the limits of probability will account for so large differences, we must therefore still further reduce the width of the rings.

By trying different values, it will be found necessary to diminish $r'-r$ so far, that the intervals occupy nearly as much area as the reflecting surface, which cannot be admitted, for reasons before given.

We will take $r'-r=0{\cdot}02$, which corresponds to eleven equal rings distant from each other by 0·01.

For the outside ring,

$t=0{\cdot}59$ $\qquad$ $f>0{\cdot}0023$ $\qquad$ $f'>0{\cdot}0202$

$f=-0{\cdot}0036$, tendency is from the surface.

$f'=\ 0{\cdot}0144$

$r'-r<0{\cdot}0097$ computed.

$r'-r=0{\cdot}0200$ assumed.

For the middle ring,

$f > 0{\cdot}0172$ $\quad f' > 0{\cdot}0205$ $\quad t = 0{\cdot}46$

$f = 0{\cdot}0046$ $\quad f' = 0{\cdot}0075$

$r' - r < 0{\cdot}0064$ computed.

$r' - r = 0{\cdot}0200$ assumed.

For the inner ring,

$f > 0{\cdot}0415$ $\quad f' > \ 0{\cdot}0288$ $\quad t = 0{\cdot}34$

$f = \ {\cdot}0113$ $\quad f' = -0{\cdot}0004$

$r' - r < 0{\cdot}0031$ computed.

$r' - r = 0{\cdot}0200$ assumed.

In order to preserve the mass as previously adopted, we must suppose an average density about three times that of *Saturn*. By recomputing f and f' for the inner ring with a density $=3$, we obtain,

$f = +0{\cdot}0263$ $\quad f' = +0{\cdot}0091$

$r' - r < 0{\cdot}0101$

$r' - r = 0{\cdot}0200$

A density six times that of *Saturn* would just suffice to retain the particles on the surface of the inner ring. To effect this without changing the mass, we must diminish b in the same proportion. But the attraction of a thin and narrow ring upon a particle at the extremity of its major axis varies nearly as $b \times$ density. *Mécanique Céleste*, vol. ii, [2095]. Therefore f is not increased when we increase the density by diminishing b.

If a further diminution of width is attempted, a difficulty is encountered in the width of the intervals.

In the last case, suppose the area occupied by the intervals is already double the limit previously assigned. If we lessen the space occupied by the intervals, by bringing the adjacent rings nearer together, f decreases instead of increases.

But there are still stronger objections to a large number of small rings near to each other.

It is known in the case of a single ring, that, if it were perfectly uniform in every part of its circumference, the slightest exterior disturbance would precipitate it upon the body of the planet. To avoid this catastrophe, we must suppose each ring to be an irregular solid, its center of gravity not coinciding with its center of figure, but having a motion of rotation about the body of *Saturn*. In addition to this, a number of regular concentric rings are in a position of unstable equilibrium, by virtue of their own mutual attractions. The slightest inequality in the intervals would have the effect of throwing the whole system into confusion.

Let us suppose, for instance, that the inner ring deviate by ever so small an amount from an exact central position with ref-

erence to the ring outside it. The nearest sides commence moving together, until they come in contact. All the others must follow. The consequence of such a conflict of these masses, each urged by different velocities, corresponding to the different times of rotation of the several rings, must be fatal to the whole structure.

It is therefore again necessary that the rings be not of regular figure or density.

But if these irregularities are small, there will be only a feeble resistance opposed to their tendency to fall upon the body of the planet.

On the other hand, if they be large, they will become the source of mutual disturbances, which must end in their destruction, by causing them to fall upon each other. The smallness of the intervals between them, and the near equality in the period of rotation of two adjacent rings, will make the danger of the latter event imminent, if not wholly unavoidable.

The nearness of the rings will in any case render it impossible that they can assume a figure of equilibrium permanent or nearly so.

The hypothesis that the whole ring is in a fluid state, or at least does not cohere strongly, presents fewer difficulties.

There being no longer an unyielding coherence between the particles of the inner and outer edges, they have not necessarily the same period of rotation about *Saturn*. A continual flow of the inner particles past the outer may be supposed, by which the centrifugal force will be brought into equilibrium with the other forces. And even should an accumulation of disturbances, of which the absence of inequalities lessens the probability, bring the rings together, the velocities at the point of contact will be very nearly equal, and the two will coalesce without disastrous consequences.

If in its normal condition the ring has but one division, as is commonly seen, under peculiar circumstances it might be anticipated that the preservation of their equilibrium would require a separation in some regions of either the inner or outer ring; this would explain the fact of occasional subdivisions being seen. Their being visible for a short time, and then disappearing, to the most powerful telescopes, is accounted for by the removal of the sources of disturbance, when the parts thrown off would reunite.

Finally, a fluid ring, symmetrical in its dimensions, is not of necessity in a state of unstable equilibrium with reference either to *Saturn* or to the other rings.

Art. XV.—*On the Constitution of Saturn's Ring;* by Prof. B. Peirce of Harvard University.

Abstract of a paper read before the American Association for the Advancement of Science, at the meeting at Cincinnati.

A memoir upon Saturn's Ring, by Mr. George P. Bond, was read to the American Academy of Arts and Sciences, upon the 15th of April, and was the occasion of the present investigation. Since Mr. Bond's paper is still unpublished, I shall be obliged to make constant reference to it, and even recapitulate some parts of it, in order that the proper relation of the two paths of research may be correctly understood.

1. The author of the Mecanique Celeste proved that Saturn's ring, regarded as solid, would not be sustained about the primary, unless it had decided irregularities in its structure. But the observations of Herschel and others have failed to detect any indications of such irregularity, and a laborious series of observations have finally convinced Mr. Bond of the utter improbability of any important irregularities, and he has, therefore, adopted the conclusion that *Saturn's ring is not solid but fluid.* Mr. Bond's argument is chiefly derived from observation; whereas a new investigation of the mechanical conditions of the problem has led me one step further. I am now convinced that *there is no conceivable form of irregularity and no combination of irregularities, consistent with an actual ring, which would permit the ring to be permanently maintained by the primary if it were solid.* Hence it follows, independently of observation, that Saturn's ring is not solid. And now it is worthy of remark that if we adopt, as the basis of calculation, the mass of the ring which was determined by Bessel, the thickness from Bond and the other dimensions from Struve, we shall find the density to be about one-fourth more than water. So that the ring consists of a stream, or of streams of a fluid rather denser than water, flowing around the primary.

2. Mr. Bond next undertook a series of very ingenious and novel computations, in order to determine from theoretical considerations alone whether the ring was one or many, and arrived at the remarkable result that *neither of these hypotheses was tenable.* He is, therefore, disposed to reconcile the discrepancies of observation in this respect by supposing the constitution of the ring to be variable; and that, although the principal division, which has been always observed, is permanent, *the other divisions are constantly annihilated by the mutual concussions of the rings, and again reproduced by some process which he does not undertake to define.* This bold theory is fully sustained by my own analytical investigations, and not only do my researches ex-

hibit the possibility of this strange phenomenon, but they even show the precise mode of action and how it must be the case of nature. If the ring had been originally one, it would soon have subdivided itself at definite points, which can be exactly computed, into portions of a determinate width. The disturbing causes must, however, drive these separate rings, sooner or later, against each other. There must then follow an interchange and crossing of currents, a mutual retardation, a momentary state of equilibrium as one ring and then another was breaking up, when the same process would be repeated in endless succession.

3. But even a fluid ring would not be permanently retained by the direct action of the primary. For whatever may be its figure, the velocity of its current must be slower at the points which are more remote from the planet; so that there must be an accumulation of fluid at these points. An exact analysis shows that the accumulation precisely balances the greater distance, and hence the ring is attracted equally in every direction. The regulating action upon the motion of the center of gravity is, therefore, cancelled; and it must continue to move uniformly in any direction in which it may have been started by a foreign influence. It must move on until it is destroyed by striking the surface of the planet. How has Saturn's ring escaped this catastrophe? Simply, because the disturbing forces have counteracted their own effects. The satellites are constantly disturbing the ring; but, in the very act of perturbation, they are sustaining it in its place. Their sustaining action is not negative, but positive; and without satellites there can be no ring. The theory of this curiously sustaining power may be variously illustrated. In the first place, each particle of the ring may be regarded as a satellite, which the other satellites disturb in the usual way. Thus the mean distance from Saturn is not varied in the least, and the disturbance of the eccentricity can only reach certain definite limits, after attaining which it must diminish. Secondly, in consequence of the attraction of its satellites, Saturn describes an orbit about the common center of gravity of the system; each particle of the planet tends to move in this same orbit. The center of gravity of the ring must, likewise, tend to describe nearly this same orbit, and its orbit would be precisely the same if the attraction of the ring for the satellites were the same as if its mass were accumulated at its center of gravity. But the deviation may be safely neglected and referred to the class of periodical perturbations.

4. It follows, then, that no planet can have a ring, unless it is surrounded by a sufficient number of properly arranged satellites. Saturn seems to be the only planet, which is in this category; and it is the only one, therefore, which could sustain a ring. Our Sun, also, does not appear to have its satellites properly disposed

for supporting a ring; and the only part of the system where such a phenomenon might have been reasonably expected, is just within the powerful mass of Jupiter. But had there been a ring at this part of the system, it must have been subject to such extraordinary perturbations, that it would in the course of time have been vibrated up against the next interior planet, Mars; and, in this way, have been broken into the asteroids. The orbits of planets formed under such circumstances would have been naturally characterized by great eccentricity.

5. But suppose that, from any cause whatever, the Sun had, at some period, been surrounded by a light ring comparable in levity to the zodiacal light; and in order to escape the planetary influences, we may suppose the plane of the ring to have had a large inclination to the ecliptic. The result would have been that the center of gravity of the ring would have soon begun to move in some direction or other, and have continued moving until it was brought against the surface of the Sun. But during this motion, and in consequence of the solar action, the matter of the ring would have accumulated at the most remote part; so that if the Sun were a mere point, it would have happened that, at the very instant of its expected meeting with the ring, the whole ring would have escaped from the point of compact. The experiment of Tantalus would have been performed on a grand scale, and the ring would have been instantaneously transformed into a comet in its aphelion.

6. If, however, the ring were supposed to be a large gaseous mass of a circular figure, the condensation which would occur at the point of aphelion might soon lead to chemical action. Precipitation might ensue, and the necessary consequence would seem to be a continually accelerated accumulation at this point, which would terminate in the production of a planet.

I stop upon the verge of the nebular hypothesis. I appeared before this Association a few years ago when it was still in its primitive geological condition, with an argument which seemed to me at the time to be incontrovertible, against this theory. I then maintained that, although it stood upon three legs, it was nevertheless infirm in its position; for that one leg was too long, a second was too short, and the third was wholly dilapidated. I am not yet disposed to retract my opposition, nor shall I, at once, sacrifice my former unanswerable arguments upon the altar of a new investigation. But I am free to admit that the farther I extend my researches into the physical universe, the stronger appears to me the evidence that the process of creation was conducted by the divine geometer in a modified form of that very hypothesis, which was contrived by a shallow and wicked philosophy for the direct purpose of excluding the Deity from his own works.

Art. XVI.—*On Saturn's Ring;* by Daniel Kirkwood, A.M., Principal of Pottsville Academy.

Messrs. Editors:—I have just seen an abstract of Prof. Peirce's paper, "*On the Constitution of Saturn's Ring*," read before the American Association at its recent session in Cincinnati. I had for some time doubted the truth of the generally received theory of the solidity of this extraordinary girdle. To myself, therefore, the reasoning and conclusion are especially interesting. The following remarks on the same subject are taken from a lecture written a year since, and publicly delivered in the city of Reading on the 3d of January last. Should you deem them worthy of publication they are at your disposal.

The late discovery of a remarkable harmony in the rotations of the planets, gives additional interest and importance to a variety of questions bearing upon the theory of the genesis of our system. The rotation of Uranus—the physical constitution of the Sun—the law of the planetary distances—the relative ages of the planets—the rings of Saturn—all are subjects claiming the earnest attention of scientific men, and holding out encouraging hopes of future discoveries.

* * * A mistake appears to have generally obtained with respect to the epochs at which, according to the nebular theory, the various members of our system assumed a planetary form. "In this hypothesis," remarks Poutecoulant, "the formation of the planets would not have been simultaneous; they have been created successively at intervals of ages; the oldest are those which are farthest from the Sun, and the satellites are of a more recent date than their respective primaries." On the same subject Prof. Lovering, of Cambridge, Mass., says:—"It cannot be declared to be beyond the reach of the enginery of the mathematician, to be able to settle with exactness the genealogy of our system according to Laplace's theory, and to assign the individual year when each of the outcast planets, from the gray Herschel and Saturn down to the infant Mercury, left its burning home and became an independent orb." In regard to this question it may be proper to remark, that the epoch of the disjunction of a ring from the central mass, and that of its assuming a spherical form, would be separated by an immense interval. The most distant annuli, or those first abandoned, would require a much longer period to agglomerate around a nucleus than those of more recent origin. It is evident also that the planets having a greater "sphere of attraction" would require a proportionally greater length of time for the process of condensation. Taking these facts into consideration, it would seem that the planets nearest

the Sun may have been the first to assume their present dimensions. Of the major planets, Saturn has the greatest "sphere of attraction," and hence the duration of its *forming period* must likewise have been greatest. This gives rise to the interesting question whether the ring of Saturn may not be the most recent cosmical formation within the limits of the solar system, and whether it may not, in the course of future ages collect about a nucleus and constitute a satellite. The evidence of its solidity is not, I think, by any means conclusive. On the other hand, observations made within the last few years give a degree of plausibility to the presumption that it may be in a state of fluidity. I refer to the occasional appearance of dark lines, chiefly on the outer ring, which have been supposed to indicate a subdivision into several concentric annuli. They do not, however, appear to be permanent; at least they are subject to some change, as they are not always visible, even when circumstances would seem most favorable. It has also been found by delicate micrometrical measurements of the rings, that they are not of uniform thickness. May not this accumulation of matter on one side be the incipient nucleus of a satellite? If so, it will be reserved for future astronomers to witness a scene no less amazing than the formation of a new world within the limits of the solar system.

If we admit the truth of the nebular hypothesis, it becomes an interesting question whether the chaotic matter advanced with regularity through all the stages of condensation, or whether its contractions were sudden and violent. The former supposition appears to have been generally entertained by writers on the subject; but the latter, as has been observed by Prof. Nichol, seems more in harmony with the known operations of nature around us. When gaseous substances pass to a liquid state it is not generally by gradual condensation: on the other hand, such changes are characterized by rapid and energetic action. The same is true in most cases when a body passes from a liquid to a solid state.

It affords me the highest gratification to know that the attention of some of the most distinguished mathematicians of our country has been directed to the investigation of the interesting questions to which I have referred. And although in all probability the subject cannot be exhausted for many years—perhaps for ages—the progress of research leaves little room to doubt the speedy development of important results.

Pottsville, Pa., May 19th, 1851.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Rotation of the Plane of Polarization produced by the Galvanic Current.*—Wiedemann has presented a memoir upon this subject which is of special interest and importance from its containing the results of the only series of *quantitative* experiments with which science has been enriched. The apparatus employed was similar in principle to that used by Bloch in his determinations of the power of rotation of rock-crystal with reference to the fixed lines of the spectrum. A ray of light was introduced into a dark room by means of a heliostat, and after passing through a narrow vertical slit traversed the polarizing apparatus which consisted of two Nicol's prisms, the first fixed, the second moveable round its axis and carrying a vernier applied to a graduated circle and reading to 5′. Between the two Nicol's prisms was placed the substance to be examined. Behind the second Nicol, at a distance of from 6 to 8 feet, was placed a Galilean telescope magnifying about 15 times, and in front of the objective of this, a flint glass prism which received the rays which had traversed the polarizing apparatus. Under these circumstances the light was polarized by the first Nicol in a definite plane which by the action of the interpolated substance received an angular deviation, and this deviation was of course different for rays of different colors; the second Nicol then extinguished that color the plane of polarization of which was perpendicular to the plane of vibration of the Nicol. The spectrum formed by the flint-glass prism and observed through the telescope exhibited therefore only those colors which had passed through the polarizing apparatus, and these with a greater or less brightness according as their plane of vibration was less or more inclined to the plane of vibration of the second Nicol. In place of the color extinguished by this last, a black band was seen in the spectrum: when the second Nicol is turned round this band wanders from one end of the spectrum to the other, as the plane of vibration of the Nicol becomes successively perpendicular to the planes of polarization of the different colors. In the unextinguished portion of the spectrum the lines of Fraunhofer were distinctly to be seen; the cross-wires of the telescope were then brought to coincide with one of these lines, and then the second Nicol turned till the dark band in the spectrum coincided with the wires and consequently also with the fixed line selected; the angle through which the Nicol had been turned gave then the angle of rotation corresponding to the given fixed line. In this manner it was easy to determine the angle of rotation for the different wave lengths corresponding to the lines B, C, D, E, b, F and G, as had been done by Bloch for plates of rock crystal. To test the accuracy of the method, oil of lemon and different kinds of oil of turpentine were examined; the results reduced to lengths of 100^{mm} were as follows:

	B	C	D	E	b	F	G
1. Turpentine,		10·9	14·05	18·7	19·6	23·2	32·75
2. Turpentine,	21·5	23·4	29·3	36·8	38·3	43·6	55·9
3. Oil of lemon,	34·0	37·9	48·5	63·3	66·4	77·5	106·0

The turpentine No. 1, was pure and had been rectified in a current of steam, its rotation was towards the right; No. 2, was another variety which had not been rectified and turned the plane of polarization to the left; the oil of lemon was also pure and distilled like No. 1: the author found that with pure oil of turpentine the observed angles of rotation never differed more than 5′ from the mean, whereas with oil of lemons the differences were much greater, the turpentine was therefore preferred for experiments with the galvanic current. The galvanic apparatus employed consisted of two helices of copper wire $2{\cdot}3^{mm}$ in thickness, and weighing each about 6 lbs.; they were placed with their axes in the same straight line and had together a length of about 9 inches; in the axis of these coils was placed the tube containing the liquid to be examined. The current from a battery of about 30 pairs, (partly Grove's, partly Bunsen's and partly iron-zinc,) was made to pass through a gyrotrope, a tangents-compass, and the whole length of the coils themselves. In this manner the author studied the deflecting action of the current upon the plane of polarization in bisulphid of carbon and in oil of turpentine; the result of his investigation he gives in the following statements.

(1.) The law of Biot, according to which the rotation of the plane of polarization of any color is inversely proportional to the square of its wave length does not hold good for oil of turpentine or oil of lemon, any more than for rock-crystal, (as shown by Bloch.)

(2.) The law of Faraday, according to which the deflection of the plane of polarization is proportional to the intensity of the deflecting current, holds good for those substances, which in themselves deflect the plane of polarization, as well as for those which do not do so.

(3.) The deflection of the plane of polarization of different colors by the galvanic current is in the case of rotating as well as not-rotating substances, greater in proportion as the wave length of the color in question is less. In *rotating* substances like oil of terpentine, this deflection is proportional to the deflection produced by the substance itself upon the plane of polarization of each particular color.—*Pogg. Ann.*, 1851, *No.* 2.

2. *Physical Demonstration of the Rotation of the Earth by means of the Pendulum.*—Foucault has communicated to the Academy of Sciences an account of an experiment which has excited universal attention and interest, and which has since been frequently repeated with success. The experiment consists simply in suspending a heavy ball to a long and flexible string, and allowing the whole to vibrate freely in the manner of a pendulum; under these circumstances it will be found that the plane of vibration gradually changes its position, turning slowly from east to west. To understand what takes place in this case, it is necessary to consider first the experiment as made at the pole, and the pendulum as suspended from a point in the axis of the earth prolonged and independent of the motion of the earth itself; it is evident that in this case, as the earth moves from west to east the plane of vibration of the pendulum which is in reality fixed, will appear to move from east to west. Next suppose the pendulum suspended from a point in the axis of the earth prolonged, but attached to and moving with the earth itself, it is evident, and it may easily be demonstrated

by experiment, that the rotation of the point of suspension will not affect the plane of vibration of the pendulum, and the result will be the same as before; the plane of vibration will appear to revolve uniformly, making a complete revolution in twenty-four hours. If we transfer the point of suspension from the pole to the equator, this point will then revolve with the earth and the plane of vibration will undergo no apparent change: but if we transfer the pendulum to a point between the pole and the equator, it is clear that while the point of suspension will itself revolve uniformly with the earth, the plane of vibration of the pendulum will be carried round but less rapidly than the earth, the result will therefore be that the plane of vibration will move *with reference to the earth* from east to west, but more slowly than at the pole. Foucault finds, by two different methods, that the angular motion of the plane of vibration is equal to the angular motion of the earth in the same time multiplied by the sine of the latitude. The experiment in question has been made upon a large scale in the Pantheon at Paris, the length of the cord, and consequently the time of vibration of the pendulum allowing the apparent motion of the plane of vibration to become very distinctly evident after only a few oscillations.—*Comptes Rendus*, xxxii, p. 135. [The experiment has been repeated in this country and England.]

3. *Equivalent of Bismuth.*—SCHNEIDER has made a new determination of the equivalent of bismuth, and has obtained results which appear to be well worthy of confidence. Commercial bismuth was dissolved in pure nitric acid, the solution precipitated by the addition of water, and the resulting basic nitrate thrown upon a filter, and well washed and dried; the dry salt was then mixed with black flux and the mixture ignited; the regulus of metallic bismuth thus obtained was fused several times with the addition of a small quantity of nitre, then again fused repeatedly alone, and finally poured out upon a clean porcelain plate. The mode of determination employed was that of oxydation, as the reduction of the oxyd by means of hydrogen takes place with difficulty and at a temperature at which some of the oxyd is volatilized. A known weight of the metal was dissolved in pure nitric acid, the solution evaporated to dryness and ignited, and the resulting oxyd weighed. For the precautions used to prevent loss by the mechanical transfer of small portions of the solution, and other causes, we must refer to the original memoir. As a mean of eight experiments nearly agreeing with each other, it was found that 100 parts of oxyd of bismuth contain

Bismuth, ...	89·655
Oxygen, ...	10·345

from which the equivalent of bismuth is found to be 2599·95, which of course is sufficiently nearly represented by the round number 2600. The old equivalent determined by Lagerhjelm, 2660·75, is consequently much too high, and bismuth must be placed among those elements whose equivalents are exact multiples of that of hydrogen, $2600 = 12{\cdot}5 \times 208$. —*Pogg. Ann.*, 1851, 2, 303.

4. *Equivalent of Tungsten.*—MARCHAND and SCHNEIDER have determined the equivalent of tungsten both by the oxydation of the metal and by the reduction of tungstic acid in a current of hydrogen. As a

mean of four experiments, two by reduction and two by oxydation, Marchand found 1150·6; as a mean of eight experiments, five by reduction and three by oxydation, Schneider found 1150·78, the first series giving 1150·39, the second 1151·17. We may therefore safely infer that the equivalent of tungsten does not differ by a unit from 1150. —*Ann. der Chemie und Pharmacie, Feb.*, 1851, 262.

5. *Action of Light upon the Iodid of Ethyl.*—FRANKLAND has studied the action of light upon the iodid of ethyl and has discovered a new and remarkable analogy between hydrogen and the homologous radicals, methyl, ethyl, amyl, &c. Iodohydric acid as is well known when exposed to the light in a well closed flask gradually becomes brown from the separation of iodine, and the decomposition is continuous if the free iodine be removed as fast as formed. Iodid of ethyl is also discolored by exposure to light and the products of its decomposition under these circumstances form the subject of Frankland's investigation. A number of glass balloons containing each about ten ounces were filled with mercury and inverted into a cistern of the same metal; a few drops of iodid of ethyl were introduced into each balloon by means of a pipette and the balloons were then exposed to the sun's rays. The surface of the mercury was speedily covered with a thin layer of subiodid which subsequently became protiodid while bubbles of gas were evolved so as gradually to expel the mercury from the balloon; the action was greatly increased by employing a parabolic reflector to concentrate the rays of light, the temperature never being allowed to rise as high as the boiling point of the iodid, 71·6 C. After a few hours the balloons were filled; the gas contained was then allowed to stand over a solution of sulphid of potassium to absorb the vapor of iodid of ethyl and afterward submitted to analysis; it was found to consist of

Ethyl, - -	(C_4H_5) - - -	67·76
Hydruret of ethyl,	(C_4H_5, H) - -	17·90
Olefiant gas, -	(C_4H_4) - -	14·34

The decomposition of the iodid in the presence of mercury may therefore be represented by the equation, $C_4H_5I + Hg = C_4H_5 + HgI$.

A small portion of the ethyl is at the same time decomposed into hydruret of ethyl and olefiant gas, $2C_4H_5 = C_4H_5, H + C_4H_4$.

It appears therefore that the action of light upon the iodid of ethyl is precisely similar to its action on iodid of hydrogen, and furthermore that the decomposition which here takes place is analogous to that which the iodid of ethyl undergoes at a high temperature in presence of zinc. The presence of water was found to have no influence on the products of the decomposition of iodid of ethyl by the sun's rays. The author suggests the employment of iodid of ethyl as an actinometer or instrument to measure the intensity of the chemical action of the sun's rays; a very faint and diffuse light is sufficient to evolve a considerable volume of gas which might be easily measured and corrected for temperature, pressure, and tension of the vapor of undecomposed iodid. The author closes his most interesting memoir with an elaborate, and as it appears to us, most successful defence of his views of the nature of the hydro-carburets, C_2H_3, C_4H_6, and C_4H_5.—*Ann. der Chemie und Pharmacie*, lxxvii, 221.

6. *On a series of Alkaloids homologous with Ammonia.*—WURTZ has at length published in detail the results of his researches on the series of organic bases discovered by himself more than two years ago, and since partially described in various scattered notices. The bases in question were obtained by one of three different reactions, by the action of potash on the cyanic ethers, by the action of potash on the cyanuric ethers, or by the action of potash on the ureas. To these modes of preparation Hofmann has, as is well known, added a fourth, namely the action of the iodids or bromids of ethyl, methyl, &c., upon ammonia, and others still have been discovered by Strecker, Anderson, Rochleder and Wertheim.

We shall confine ourselves here to a notice of those properties of the new bases which have not hitherto been fully described. Methylamine is readily prepared by distilling its chlorohydrate with twice its weight of caustic lime and collecting the gas evolved over mercury. It is a colorless gas which condenses a few degrees below 0° into a highly mobile liquid; its odor is strongly ammoniacal; in water it is more soluble than any other gas with which we are acquainted; 1 vol. of water at 12°·5 C. dissolves 1154 volumes of methylamine. It readily inflames and burns with a yellowish flame yielding water, carbonic acid, and nitrogen; with chlorohydric or carbonic acid gas it readily unites, forming white solid salts; the chlorohydrate is deliquescent. The aqueous solution of methylamine strongly resembles aqua ammonia, the gas is expelled by boiling and the solution precipitates a large number of metallic oxyds and dissolves some of them when added in excess; the salts of magnesia, manganese, iron, bismuth, chromium, uranium and tin are precipitated as by ammonia; the salts of copper and zinc are also precipitated and the precipitates are redissolved by an excess of the alkali. Nitrate of silver is completely precipitated by a solution of methylamine: the resulting oxyd is readily dissolved in the alkaline solution and when the liquid is allowed to evaporate spontaneously a black substance is formed containing carbon, hydrogen, nitrogen and silver and probably corresponding to fulminating silver: it does not explode however either by heat or by a blow. Passed through a red hot porcelain tube, methylamine yields cyanhydrate of ammonia, prussic acid, marsh gas and hydrogen. Iodine instantly acts upon a solution of methylamine and is transformed into a garnet-red powder represented by the formula $C_2H_3I_2N$, and corresponding to the so-called iodid of nitrogen which is doubtless HI_2N; it does not explode by heat. When protochlorid of platinum is heated with a solution of methylamine a green precipitate is obtained corresponding to the green salt of Magnus, and from this a new base may be obtained analogous to that known as Reiset's base and represented by the formula, $C_4H_3PtN_2$ or $NH_2(C_2H_3)+NHPt(C_2H_3)$. The oxalate of methylamine yields by dry distillation, methyloxamid, $C_2O_2, NH(C_2H_3)$ which may be regarded as oxamid in which one eq. of hydrogen is replaced by one eq. of methyl; in like manner the acid oxalate of methylamine yields methyloxamic acid, $C_2O_3+C_2O_2, NH(C_2H_3)$. Ethylamine is readily obtained from its chlorohydrate by distillation with lime and condenses in a cool receiver as a limpid colorless liquid which boils at 88°·7: its density at 8° is 0·6964; it possesses an ex-

tremely penetrating ammoniacal odor and its causticity is comparable with that of potash; it changes vegetable colors from red to blue and neutralizes acids as completely as ammonia; ignited it burns with a yellowish flame. With water ethylamine is miscible in all proportions, the solution strongly resembles the solution of methylamine in its chemical properties; like a solution of caustic potash it readily dissolves alumina. Ethylamine is a stronger base than ammonia and displaces this from its saline combinations, if a large excess of a solution of ethylamine be added to salammoniac, and the whole evaporated to dryness, there remains only chlorohydrate of ethylamine. Chlorine, bromine and iodine react with a solution of ethylamine yielding compounds represented by the formulas $C_4H_5Cl_2N$, $C_4H_5Br_2N$, $C_4H_5I_2N$; the chlorine compound is decomposed by caustic potash giving acetate of potash, ammonia and chlorid of potassium,

$$C_4H_5Cl_2N+3KO+HO=KO,C_4H_3O_3+NH_3+2KCl.$$

It does not possess basic properties and is probably $NCl_2(C_4H_5)$. Ethylamine yields with protochlorid of platinum compounds analogous to those formed by methylamine. The author describes also ethyloxamid and ethylacetamid. Amylamine prepared in the same manner as the other two bases is a colorless highly fluid liquid: it boils at 95° and its density at 18° is 0·7503; it is highly caustic and possesses the odor of ammonia and at the same time of the amyl compounds; exposed to the air it attracts carbonic acid and yields a crystalline carbonate; with water it is miscible in all proportions. The author describes only the chlorohydrate, bromhydrate and amyloxamid. With regard to the theory of the constitution of the new bases, Wurtz inclines to the view of Hofmann, namely, that they are to be regarded as ammonia in which an equivalent of hydrogen is replaced by an equivalent of methyl, ethyl, or amyl; we have therefore,

Methylamine, ...	$NH_2(C_2H_3)$
Ethylamine, ...	$NH_2(C_4H_5)$
Amylamine, ...	$NH_2(C_{10}H_{11})$.

Ann. de Chimie et de Physique, xxx, 443.

7. *Constitution and products of the decomposition of Codein.*—Anderson has presented an elaborate investigation of codein and its compounds. Crystallized codein dried at 100° loses two equivalents of water and its formula is then $C_{36}H_{21}NO_6$, as first correctly determined by Gerhardt; it is a powerful base, changes vegetable reds to blue, and precipitates the oxyds of lead, copper, iron, cobalt, nickel and other metals from their saline solutions. Potash precipitates codein from its solutions but redissolves the precipitate when in great excess; ammonia also precipitates it after a short time in small transparent crystals; the author describes various salts all of which may be obtained crystallized. Moderately strong sulphuric acid converts codein into an amorphous substance which possesses the same constitution as codein itself. Nitric acid converts codein into a new base, nitrocodein, $C_{36}H_{20}(NO_4)NO_6$, which is crystalline and yields several crystalline salts: bromine gives with codein two new bases, bromcodein and tribromcodein, represented by $C_{36}H_{20}BrNO_6$ and $C_{36}H_{18}Br_3NO_6$; chlorine yields with codein a chlorinated base, $C_{36}H_{20}ClNO_6$. A concentrated solu-

tion of codein absorbs cyanogen with avidity and yields a new base dicyanocodein, $C_{40}H_{21}N_3O_6$ or $2C_2N$, $C_{36}H_{21}NO_6$. Distilled with four or five times its weight of soda-lime or potash-lime, codein yields several organic bases among which Anderson succeeded in identifying methylamine and propylamin, C_6H_9N.—*Ann. der Chemie und Pharmacie, March*, 1851, lxxvii, 341.

8. *Acetic Acid from Sea-weeds.*—STENHOUSE has found acetic acid in considerable quantity among the products of the fermentation of various species of sea-weed. Fucus nodosus yielded 1·45 per cent., Fucus vesiculosus 1·15 per cent. of the weight of the moist plant.

W. G.

9. *New Test for the Nitrites and Nitrates;* by GEORGE C. SCHAEFFER, Prof. of Chem. and Nat. Phil., Centre Coll., Danville, Ky., (Proc. Amer. Assoc., 4th meeting at New Haven, 1851, p. 403.)—Chemistry has hitherto furnished no distinctive test for the nitrites, when present in small quantities. From the supposed unfrequent occurrence of these salts, the want of such a test has never been felt.

For several years I have been engaged in a research which has led me to believe that the nitrites are of far more frequent occurrence than is commonly supposed, and that they have been mistaken for nitrates, as the usual process, with pure sulphuric acid and protosulphate of iron, will give the same reaction with both classes of salts. In order to settle the question, it was necessary to find a distinctive test, which should avoid all risk of confusion. I first tried acetic acid, which, as is well known, does not act upon the nitrates, while it decomposes nitrites. By substituting this acid for the sulphuric in the usual process, I succeeded perfectly. The test seemed even more delicate than that for the nitrates, and was more elegant in its operation.

Still the following difficulties were to be encountered. The slightest quantity of peroxyd in the sulphate gave a color with acetic acid, and injured the delicacy of the test. Moreover, the nitrites are generally either destroyed or converted into nitrates, with such readiness, that it would be almost impossible to concentrate their solutions.

At last I was led to the following process, which leaves nothing to be desired. To the solution supposed to contain a nitrite, add one or two drops of solution of yellow prussiate of potash—there should not be enough to give a perceptible tinge to the liquid. A few drops of acetic acid are then to be added, and immediately, or in a few minutes, according to the quantity of nitrite present, the liquid assumes a rich yellow tint.

As the re-agents used give nearly the same color, spontaneously, after some time, even in pure water, it is better, when testing for minute quantities, to use two similar vessels, one containing pure water, and the other the liquid under examination, to both of which the re-agents are to be added in precisely equal quantities. The vessels should be equally exposed to the light, with a sheet of white paper behind them.

With these precautions, I have found this test astonishingly delicate, in fact, ranking with those for iron, iodine, &c. Using fused nitre, I have detected the presence of one pt. in 617,000 pts. of water; a by-stander wholly ignorant of the nature of the operation, pronouncing as to the color. Yet this salt contained about one-half its weight of undecomposed nitrate.

It should be remarked that the presence of a large quantity of nitre has no influence upon this test, as with pure water it gives no color. The same reaction answers also for the hyponitrates.

The next step is to convert this test into one for the nitrates. The decomposition of the nitrates of lead and mercury by boiling with excess of their respective metals, has long been known. The reaction of metals with the alkaline nitrates does not seem to have been studied. I find that nitrate of ammonia is readily decomposed in presence of metallic lead, and what seems surprising, nitrate of potash is also decomposed, though not so readily.

To test for the nitrates, we have only to agitate the slightly warmed liquid, for a few minutes, with shavings of lead, and proceed as before. By a longer digestion more of the salt would be converted into nitrite, and the color would be stronger. In estimating the delicacy of this process, I had used pure rain water, but before completing the experiments I was obliged to be absent for several days; on my return, I soon found that the water from the same cistern contained so much of nitrates and nitrites, that it could no longer be used. From the readiness with which the decomposition was effected, I presume that nitrate of ammonia was present. The interval had been marked by the occurrence of frequent and severe thunder showers.

By using distilled water, I have been able to detect the presence of one pint of nitre in about 60,000 of water, digesting with lead for only a short time. Mercury containing a minute quantity of lead, seems to answer better than lead, for a time, in the above process; but after long use it loses its effect. It will not answer to add to it any perceptible quantity of lead, as the liquid then becomes muddy on agitation.

Oxalic, tartaric, and dilute hydrochloric acids may be substituted for the acetic, except when they produce precipitates, which would destroy the clearness of the liquid.

The yellow color produced in this test is the result of a complex decomposition. Everitt's yellow salt, and red prussiate, seem to be formed, and in some cases also very minute quantities of Clayfair's nitroprussid.

II. Geology.

1. *On the Parallelism of Mountain Chains in America;* by Mr. Desor, (Proc. Boston Soc. Nat. Hist., Dec., 1850, p. 380.)—It is generally admitted that the Appalachian or Alleghany chain was raised during the deposition of the coal formation. It is consequently referred by Mr. Beaumont to his system of the Balloons, the direction of which (E. 16° S.), when transferred to Washington, becomes E. 43° 18′ N., a direction which indeed answers pretty accurately to that of the main portion of the Alleghany chain. This is also, according to Dr. C. T. Jackson, the main direction of the hills of New Hampshire and Maine. But there is besides in the Alleghanies another direction more nearly parallel to the meridian, which Professor Rogers considers as a mere deviation from the main direction, whereas Mr. Beaumont refers it to a previous upheaval, together with those ranges of hills in Massachusetts which Prof. Hitchcock has designated as the "oldest meridional system,"

and whose direction is a few degrees east of north. According to Mr. Beaumont, this latter system would not only be older than the Alleghanies, but even older than the oldest Silurian strata of North America, since it is supposed to have originated previous to the Taconic system.

Now to this system is ascribed a most conspicuous part in the constitution of the soil, not only of New England but of the whole continent, so that if true it must be of paramount importance. From Massachusetts, Mr. Beaumont traces it in a south southwest direction to the mouth of the Connecticut, and in the opposite direction across New Hampshire and the White Mountains to the sources of the Connecticut, from whence it extends across Labrador to Cape Chisley; nor is it supposed to stop here, for Mr. Beaumont follows it even beyond Davis' Strait into Greenland. The range is said to be not less extensive in the southern direction. Representing it as a great circle, starting from Amherst College in a direction south 15°, he supposes it to run parallel to the general direction of the coast of the United States from the mouth of the Hudson to Cape Hatteras. From thence it is supposed to cross the eastern portion of Cuba, the Isthmus of Panama, and then to touch Cape Guyaquil, passing a little outside of the Coast of Choco, in a direction parallel to the principal mountain chains of New Grenada.

This system, thus laid down, is considered by Mr. Beaumont as one of the most remarkable mineralogical and metalliferous zones of the globe, including all the localities whence are derived the remarkable minerals of Greenland and Labrador, the gold mines of Vermont,* Virginia, North and South Carolina, Georgia, the several gold mines of Cuba, the gold and platinum mines of Hayti, and the gold and platinum mines of Choco and the Eastern Cordilleras in New Grenada.

If we now ask for the reason why this immense belt should be so much older than any other mountain chain of this continent, we are referred to the single statement, that in New Hampshire and Vermont the primary rocks following this direction are overlaid unconformably by the strata of the Taconic system. And since the Taconic system is supposed by Mr. Beaumont to be older than the oldest Silurian, the inference on his part was but natural, that the ridges of New Hampshire, Vermont, and Massachusetts must indeed be very old. They were thus made the point of departure of this vast system, to which most of the above-mentioned localities were added merely on account of their direction or of the minerals which they contain.

Now that serious doubts are entertained as to the existence of a Taconic system in New England, especially since it has been proved by the investigations of the geologists of Canada that the slates of the Green Mountains, which were referred to the Taconic, belong in reality to the Silurian formation, the theory of Mr. Beaumont cannot longer be relied upon, being thus deprived of its principal basis. If it is once ad-

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* After the reading of Mr. Desor's paper, Mr. Alger observed, that the gold found in Vermont, which he supposed was the authority for M. De Beaumont's allusion to the gold mines of that state, had proved to be of artificial origin. It was gold which had been thrown into a stream forty or fifty years since by counterfeiters, who were suddenly disturbed in their counterfeiting operations.

mitted that the Green Mountains are not Taconic but Silurian rocks, there is no reason why we should not refer them simply to the age of the Alleghanies, the more so as we have direct evidence in the raised conglomerates of Massachusetts, that at least some of the ridges of New England are not of an earlier age than the coal formation.

How far this reasoning might apply to the many other regions connected by Mr. Beaumont with this supposed oldest Meridional system, Mr. Desor was unable to say, but observed, that with all due regard for the great abilities of his illustrious teacher, he thought there was no sufficient reason for upholding any longer this peculiar system, unless it be established on better proofs.

In removing thus this so-called oldest Meridional system from its prominent place, it is not a little interesting to notice that those ranges of hills and mountains which are actually known to have been raised previous to the deposition of the oldest fossiliferous rocks, such as the primitive mountain ranges on the north bank of the St. Lawrence, the granite ranges of Lake Superior, and the iron-bearing old slates of that country are all more or less parallel to the equator. It would seem as if in these early times, there had been a prevailing disposition on the part of the earth crust to wrinkle in that direction. (We take it for granted that these old hills are the result of a shrinkage in consequence of the cooling of the earth's surface rather than a positive upheaval.) It is only at a later period that we meet with wrinkles running in the opposite direction (north and south).

2. *Lower Silurian Reptile in Canada*, (From Lyell's Anniv. Address before the Geol. Soc. of London, Feb., 1851, p. 59.)—I have not alluded in this Address to the recent discovery of the track of a quadruped imprinted on a lower silurian sandstone in North America. We are indebted to Mr. Logan, now at the head of the Government Survey in Canada, for having carefully determined the position of the rock containing it. The locality is the village of Beauharnois, on the south side of the St. Lawrence, twenty miles above Montreal. The rock, a fine-grained whitish sandstone, quarried for building, belongs to the group called the Potsdam sandstone by the New York surveyors, and lies at the base of the whole fossiliferous series of North America. The markings were first pointed out to Mr. Logan by Mr. Abraham, editor of the Montreal Gazette, who appreciated their geological importance. Assuming the Chelonian origin of these foot-prints, they constitute the earliest indication of reptile-life yet known, and are not only anterior to the most ancient memorials of fish hitherto detected, but agree in date with the first known signs of well-defined organic bodies, such as Lingulæ, met with in the same rock. Professor Owen, of the College of Surgeons, has examined a slab of the sandstone, on the upper surface of which the foot-prints are impressed, together with a plaster cast of the remainder of the continuous trail, in all $12\frac{1}{2}$ feet long, brought to London by Mr. Logan; and the Hunterian Professor has had the kindness to communicate to me the following description.*

"The impressions are more numerous in regular succession than any that have been previously discovered; so that the evidence of

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* R. Owen—Letter to Sir C. Lyell, March 18th, 1851.

their having been made by successive steps, afforded by this succession of corresponding prints at regular intervals, is the strongest we possess. They are in pairs, and the pairs extend in two parallel linear series with a groove midway between the two series. The outer impression of each pair is the largest, and it is a little behind the inner one. Both are short and broad, with feeble indications of divisions at their fore part. They succeed each other at intervals much shorter than that between the right and left pair.

"The median groove is well defined and slopes down more steeply at its sides than towards the bottom, at some parts of the track. I conclude from these characters that the animal which left the track was a quadruped, with the hind-feet larger and wider apart than the fore-feet; with both hind and fore-feet very short, or impeded by some other part of the animal's structure from making any but short steps; that the fore and hind limbs were near each other, but that the limbs of the right and those of the left side were wide apart: consequently, that the animal had a short but broad trunk, supported on limbs either short or capable only of short steps; and that its feet were rounded and stumpy, without long claws.

"As to the median impression, that may be due either to a thick heavy tail, or to the under surface of the trunk, dragged along the ground. The shape of the body and the nature of the limbs, indicated by the above-described characters of the steps, accord best with those of the land or freshwater tortoises, and the median groove might have been scooped out by the hard surface of a prominent plastron.

"The disproportion in the size of the fore and hind-feet is such as we find in some existing Terrapenes, e. g., the *Emys geographica*."

III. Zoology.

1. *On the Classification of the Cancroidea*; by James D. Dana.—The Cancroidea (or Crustacea Cyclometopa), like the Maioidea, are characterized by having, (1) the branchiæ 9 in number, 7 of which lie so as to form the exterior of the branchial pyramid; (2) the efferent passage from the branchial cavity passing over the lateral portions of the palate; (3) the male genital orifices situated in the base of the posterior legs and covered by the abdomen; (3) the male abdomen not narrower at base than the corresponding part of the sternum; (4) the buccal area subquadrate, and the 4th joint of the outer maxillipeds articulated with the 3d by its inner angle. The Telphusidæ have these characters, and may be considered true Cancroidea, though approximating to the Grapsoidea in the large vacant space in the branchial cavity, and having some peculiarities in the branchiæ fitting them for freshwater life.

The Corystes group also partake of the Cancroid character; yet they diverge from it, in the large outer antennæ more or less hairy, and both in this respect and in form, they approach the Hippa group, and thus have a much lower position in the series than the Cancroidea. They have no true relation in the character of the buccal area and efferent canal to the Leucosia group.

The genera Acanthocyclus and Corystoides (of Lucas) have the genital orifices, sternum and abdomen, and outer maxillipeds of the Cancroidea and Corystoidea; but the branchiæ (in Acanthocyclus at least)

are less numerous, as in the Grapsoidea. The outer antennæ are obsolete, and the inner in Corystoides have no fossettes. They are therefore genera of low grade, at the foot of the Cancroidea, and approach closely in rank to the Corystoidea.

Our grand divisions of the Cancroidea are hence,

1. Cancrinea, or Cancroidea Typica.
2. Telphusinea or Cancroidea Grapsidica.
3. Cyclinea, or Cancroidea Corystidica.

The character of the efferent passage or canal, separating the Leucosoid Crustacea or Oxystomata, is the most striking among the Brachyura. While, in all other species, this passage passes over the outer portions of the palate or prælabial area, in these, it passes over the medial portions, and terminates at the middle of the front margin of the buccal area which is therefore elongated, giving the area a triangulate outline: the character of this passage and not the form of the area is the important character of the Leucosoidea. The inner branch of the 1st pair of maxillipeds is modified to correspond, as it covers (more or less perfectly) in this and all the Brachyura the efferent passage.

The efferent passage, which affords the striking character alluded to, has its different degrees of perfection among the Cancroidea. In a large number of genera, the waters wash over the palate without any confining ridge: but in others there is a distinct ridge, running longitudinally, near the middle of either lateral half of the palate, and terminating at the front margin of the buccal area. This ridge is prominent in Eriphia, Ruppellia, Ozius, Pilumnoides, Melia (as the writer has observed) and some other genera, and is also distinct in Pilumnus. It is wanting in Cancer, Xantho, and the allied, or if a trace is to be observed, (as in Menippe Rumphii and some other species,) it does not reach to the front margin of the buccal area. We have in this character, therefore, an important distinction separating the non-natatory Cancrinea into two groups, the Cancridæ and the Eriphidæ. Mere breadth of carapax alone is of very little value as a characteristic: Xantho passes by its allied genera into species but little broader than long, and so with Chlorodius.

Among the swimming species, a large part, as detected by De Haan, have a small lobe attached to the inner margin of the inner branch of the 1st maxillipeds: while others, as Platyonychus and the allied have no such lobe and approximate somewhat to the Corystoidea, although not properly, as we think, of that group.

The species of Lupa and Thalamita have a ridge upon the palate either side bounding the efferent passage; but there is one exception in *Lupa cribraria*, which species consequently must pertain to a distinct group from the other Lupas.

In these brief remarks on the classification of the Cancroidea, we leave much to be gathered from the following synopsis. But a few words should be offered on the genera of De Haan and Edwards; partly because the two are to some extent in conflict, and partly because several of those of De Haan are of unessential importance. The publication of the first fascicle of De Haan's Crustacea of the Fauna Japonica in 1833, preceded Edwards by a year, but the descriptions of his genera were so concise and imperfect that it was not possible for any one to have recognized them all.

Ruppellia of Edwards, and *Eudora* of De Haan, have the same typical species. But De Haan neglected to observe in the type the important peculiarity of the orbit, (its being wholly closed within so as to exclude the base of the outer antennæ, a peculiarity found in no Brachyura except a few of the Eriphidæ,) and hence his genus includes, according to his own use of it, some Xanthoid species. The two names are by no means synonyms; and adopting the group as laid down by Edwards, we are forced to adopt his generic name. Modifications to some extent may be made in accepted genera, and this we have attempted in some instances below, but not the complete perversion that would happen by giving De Haan's name to Edwards's genus.

De Haan has not recognized the distinction between the pointed and spoon-shape figures as a generic characteristic, and this makes some difficulty in substituting his names for those of Edwards, where the groups are otherwise similar. This characteristic was first employed by Leach and subsequently by Edwards. The genera of the two kinds often graduate into one another: but the parallel relation between the series is best shown by retaining them apart in separate subfamilies. Between our Xanthinæ and Chlorodinæ there is nearly a perfect parallelism. De Haan's species of the genus Xantho are in part Chlorodii.

De Haan has multiplied much the genera of swimming Crabs, by subdividing Lupa and Thalamita. This has partly arisen from an unwarranted reliance for the characteristic on the form of the 3d joint of the outer maxillipeds, as well as on that of the inner branch of the 1st maxillipeds.

In a former paper it was observed that the 3d joint of the outer maxillipeds may undergo great variations in proportion in the same genus. This is well illustrated among the Portunidæ. Amphitrite of De Haan (a subdivision of Lupa) is described as having this joint *short and oblique*. But in species of true Amphitrite, it varies from this form to a form unusually oblong. Again he makes Neptunus and Achelous differ from Amphitrite in having this joint more oblong, the reverse of which is actually the fact among many of the species examined by the writer. So Thalamita is characterized by having this same joint short, when in fact it is sometimes longer than broad. The form in one species (T. integra, *D.*) scarcely differs in relative length or obliquity from that of Lupa dicantha. Again *Oceanus* (Thalamita crucifera of Edwards) is said to have the inner branch of the 1st maxillipeds three-lobed, and *Thalamita*, as having the inner margin unidentate. The latter has the inner lobe as in Oceanus, and this makes the one tooth; the margin outside of this lobe or tooth, is straight at top in some species (T. crassimana and crenata), but excavate in others, becoming even deep and angulate in *Th. integra*, a species very near *admetus* in form and general characters. There is thus a gradual transition to the form in Oceanus. Such variations in this margin are therefore unimportant, as many other cases illustrate.

Our grand divisions are named after the larger to which they approximate. This plan might be carried farther with much profit. Thus among the five families of Cancrinea—the Cancridæ, are the *Cancrinea Typica;* the Eriphidæ, are the *Cancrinea Grapsidica*, for in the ridges of the palate as well as form they approximate to Grapsus;

the Portunidæ, are the *Cancrinea Typica Natatoria;* the Platyonychidæ, the *Cancrinea Corystidica Natatoria;* the Podopthalmidæ, the *Cancrinea Grapsidica Natatoria.* Again, among the subfamilies of Cancridæ, the Cancrinæ, are the *Cancridæ Corystidicæ;* the Xanthinæ and Chlorodinæ, the *Cancridæ Typicæ.*

The following is a synopsis of the known genera of Cancroidea.—

Legio I. CANCRINEA, vel CANCROIDEA TYPICA.

Fam. I. CANCRIDÆ.

Pedes postici gressorii. Ramus maxillipedis 1mi internus simplex. Palatum (vel area prælabiata) colliculo ad marginem anticum producto non divisum. Carapax sæpius late transversus, interdum angustus.

1. CANCRINÆ.—Antennæ internæ plus minusve longitudinales. Frons interorbitalis perangustus. Digiti acuminati.

   G. 1. Cancer,* *Leach.*—Pars antennæ externæ mobilis hiatu orbitæ omnino exclusa. Carapax latissimus.

   G. 2. Pirimela, *Leach.*—Pars antennæ externæ mobilis hiatu orbitæ non exclusa. Carapax perangustus.

2. XANTHINÆ.—Antennæ internæ plus minusve transversæ. Antennæ externæ basi firmè infixæ, parte mobili hiatu orbitæ non exclusâ. Frons interorbitalis latior. Digiti acuminati.

   1. *Regio carapacis postica convexa. Orbita hiatu externo non interrupta.*

      G. 1. Atergatis, *De Haan.*†—Margo antero-lateralis postero-lateralı longior. Pedes 8 postici compressi, cristati.

      G. 2. Carpilius, *Leach, De Haan.*—Margo antero-lateralis postero-lateralı longior. Frons sæpissime bene 4-lobatus. Ramus maxillipedis 1mi internus lobato-furcatus. Pedes 8 postici nudi, subcylindrici, non cristati.

      G. 3. Liomera, *Dana.*‡—Frons leviter 2-lobatus aut rectiusculus. Margo antero-lateralis postero-laterali non brevior. Ramus maxillipedis 1mi internus non lobatus. Pedes 8 postici nudi, subcylindrici, non cristati.

      G. 4. Liagora, *De Haan.*§—Margo antero-lateralis postero-laterali brevior. Frons leviter 2-lobatus aut rectiusculus. Pedes nudi, tarsis exceptis. Ramus maxillipedis 1mi internus non lobatus.

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* *Platycarcinus*, Milne Edwards, Crust. i, 412.

† Faun. Japon. 17.—*Cancer* of Edwards, Crust. i, 372; and *Platypodia* of Bell, Zool. Trans. i, 335, 1835.

‡ Includes *Carpilius cinctimanus* of White, Crust. Voy. Samarang, 37, pl. 7, f. 4. The lobato-furcate form of the inner branch of the 1st pair of maxillipeds in Carpilius maculatus and the allied, is so peculiar, as shown by De Haan, that it must be admitted as a generic distinction. The true Carpilii have a strongly 4-lobed margin to the front, though the front is sometimes so bent downward that the lobes are not seen in a vertical view, though distinct in a front view.

§ Faun. Japon. 19.

2. *Regio carapacis postica transversim non convexa.*

a. Caxapax versus margines frontalem antero-lateralemque *curvatim declivis.*

G. 5. ACTÆA, *De Haan*,* *Dana.*—Margo postero-lateralis brevis, sæpius concavus. Orbita hiatu externo non interrupta.

b. Carapax versus margines frontalem antero-lateralemque parce declivis.

α *Orbita hiatu externo non interrupta.*

G. 6. XANTHO, *Leach.*—Margo antero-lateralis postero-laterali longior. Articulus antennæ externæ 1mus oblongus, frontem bene attingens, articulo sequente e apicis medio articuli 1mi orto.

G. 7. EUXANTHUS, *Dana.*—*Xantho* formâ similis: articulus antennæ externæ 1mus hiatum ad summum implens, articulo sequente e latere excavato apicis orto.

G. 8. PARAXANTHUS, *Lucas.*†—*Xantho* formâ similis: articulus antennæ externæ 1mus abbreviatus processum frontis oblongum attingens tantum. Abdomen *maris* 5-articulatum.

G. 9. MENIPPE, *De Haan.*‡—Margo antero-lateralis postero-laterali brevior. Articulus antennæ externæ brevis nec frontem nec frontis processum attingens. Abdomen maris 7-articulatum.

β *Orbita hiatu externo interrupta, infra integra.*

G. 10. PANOPÆUS, *Edwards.*—Margo antero-lateralis tenuis, postero-laterali sæpius brevior, ad orbitæ angulum externum directus.

γ *Orbita infra extusque tribus dentibus instructa, uno externo, duobus inferioribus.*

G. 11. MEDÆUS, *Dana.*—Angustus, paulo transversus, [nudus,] fronte sat brevi. Margo antero-lateralis sub orbitâ productus. Abdomen *maris* 5-articulatum, segmento ultimo brevi. Pedes antici crassi, iis *Xanthi* similes.

G. 12. HALIMEDE, *De Haan.*§—Angustus, parce transversus, [villosus,] fronte breviore. Abdomen maris 7-articulatum, segmento ultimo valde elongato. Pedes antici crassi, iis *Xanthi* similes.—An *Pilumnis* propinquior?

3. CHLORODINÆ.—Antennæ internæ transversæ. Antennæ externæ basi firmè infixæ, parte mobili hiatu orbitæ raro exclusâ. Frons interorbitalis latior. Digiti instar cochlearis excavati.—Quoad genera, Xanthinæ et Chlorodinæ ferme parallelæ.

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* Faun. Japon. 18.

† Crust. D'Orb. S. Am., 18. We see no sufficient character for sustaining this genus, excepting the short basal joint of the outer antennæ.

‡ Faun. Jap. 21.—*Pseudocarcinus* of Edwards, Crust. i, 407.—*Pelæus*, Eydoux and Souleyet, Voy. de la Bonite. *Pelæus armatus* is the name given to a Sandwich Island species figured in the plates of the Bonite, but not yet described.

§ Faun. Japon. 35. Our *Medæus* has nearly the outline of Halimede, but is naked and very deeply areolate. It is a Xantho in nearly all its characters, though narrow, and having the orbit below deeply divided. On this account, I have introduced Halimede, which resembles our genus in form, in this place, not having had an opportunity to study its characters from specimens.

1. *Hiatus orbitæ internus processu basis antennæ externæ occupatus, articulum 2dum occludens.*

G. 1. ETISUS, *Leach.**

2. *Hiatus orbitæ internus basi antennæ externæ occupatus, articulo 2do non occluso.*

1. Regio carapacis postica convexa.

G. 2. CARPILODES, *Dana.*—Carapax latus, nudus, margine antero-laterali crassè rotundato. Pedes 8 postici subcylindrici, nudi. *Liomeræ* habitu similis.

G. 3. ZOZYMUS, *Leach.*†—Carapax mediocriter latus, margine antero-laterali tenui. Pedes 8 postici valde compressi, cristati aut subcristati. *Atergati* habitu similis.

2. Regio carapacis postica fere plana.

a. Carapax versus margines frontalem antero-lateralemque curvatim declivis.

G. 4. ACTÆODES, *Dana.*‡—Pedes 8 postici non cristati. *Actææ* aspectu similis. Articulus maxillipedis externi 3tius apicem vix excavatus.

G. 5. DAÏRA, *De Haan.*§—Pedes 8 postici non cristati. Articulus maxillipedis externi 3tius apice valde emarginatus.

b. Carapax versus margines frontalem antero-lateralemque vix declivis.

G. 6. CHLORODIUS, *Leach.*‖—Carapax plus minusve transversus Articulus antennæ externæ 1mus oblongus frontem bene attingens. Articulus maxillipedis externi 3tius subrectangulatus. *Xantho* aspectu similis.

G. 7. PILODIUS, *Dana.*—Carapax paulo transversus. Articulus antennæ externæ abbreviatus, processum frontis oblongum attingens tantum. *Paraxantho* aspectu similis.

G. 8. CYCLODIUS, *Dana.*—Carapax parce transversus. Articulus antennæ externæ oblongus frontem bene attingens. Articulus maxillipedis externi 3tius triangulatus, latere interiore brevissimo.

G. 9. CYMO, *De Haan.*¶—Carapax non transversus, fere orbiculatus, disciformis. Antennis *Chlorodio* affinis.

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* Part of the species (the typical) have the arm long projecting, and a broad form somewhat like Cancer. Another part, quite different in habit, have a short arm as in Actæodes, and graduate into Actæodes. The latter may well be named ETISODES.

† *Zozymus* of Leach and *Ægle* of De Haan have the same species as type, the *Z. æneus*, and De Haan makes the cristate character of the 8 posterior legs a generic character. We follow him in this respect, though adding the character dependent on the spoon-shape of the fingers, as done by Leach.

‡ Includes *Zozymus tomentosus* and the allied, in which the 8 posterior legs are not cristate. The species are closely like Actææ except in the fingers.

§ Faun. Japon. 18; *Lagostoma*, Edwards, Crust. i, 386.

‖ *Chlorodius* of De Haan (F. Jap. 13) of subsequent date, is synonymous with *Atelecyclus* of Leach.

¶ Faun. Japon. 22.

4. POLYDECTINÆ.—Antennæ internæ transversæ. Antennæ externæ basi solutæ, liberæ.—An *Pilumnis* propinquior?

G. POLYDECTUS, *Edw.**—Orbita dentibus tribus infra instructa. Manus elongata, digitis prælongis, attenuatis, uncinatis, cum dentibus tenuiter spinuliformibus sæpe armatis.

FAM. II. ERIPHIDÆ.

Pedibus maxillipedeque 1mo *Cancridis* affinis. Palatum colliculo usque ad marginem anticum producto utrinque divisum. Carapax sæpius angustus, interdum latus, latitudine ante-mediana sæpissimè majore, oculis remotis.

1. ŒTHRINÆ.—Carapax transversus, lateribus valde dilatatus et rotundatus. Antennæ internæ fere longitudinales.

G. 1. ŒTHRA, *Leach.*

2. OZINÆ.—Carapax plus minusve transversus. Digiti acuminati. Antennæ internæ transversæ. Orbita hiatu interno basi antennæ occupato instructa. Abdomen *maris* 7-articulatum.

1. *Articulus antennæ externæ* 1*mus frontem bene attingens.*

G. 1. GALENE, *De Haan.*†—Carapax transversus, longitudinaliter multo convexus, antice declivis.—An *Potamiæ* propinquior?

G. 2. OZIUS, *Leach.*—Carapax transversus, latus, fere planus.

2. *Articulus antennæ externæ* 1*mus frontem non attingens.*

G. 3. PSEUDOZIUS, *Dana.*‡—Carapax transversus, fere planus, latior, margine antero-laterali breviore.

G. 4. PILUMNUS, *Leach.*—Carapax angustus, parce transversus, sæpius convexus, margine antero-laterali breviore.

G. 5. PILUMNOIDES, *Edw.* et *Lucas.*§—Carapax angustus, parce transversus, valde convexus, margine antero-laterali longiore, bene arcuato, super carapacem postice incurvato.

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* This genus is very peculiar in the hand: both fingers are long styliform and very slender, with incurved apices, and hardly touching except at tips, and when dentate the teeth are delicate spines on the inner margin; moreover, the part of the hand anterior to the fingers is quite short. A species collected by the writer is closely like the *P. cupulifer* in most of its characters. The form of the hand is very unlike anything among other Cancroidea; and Halimede which has been supposed to be near Polydectus, has (like Medæus) the ordinary form, like that in Xantho.

The genus *Iphiculus* of White (Crust. Voy. Samarang, 57, pl. 13, f. 5), has the general characters of our Polydectus—the same villous coat, similar fingers, even to the spiniform dentation of the fingers, and other resemblances; and we suspect although a broader species, that his *I. spongiosus* is a true *Polydectus.*

The specimen of the Polydectus, from which a description with a colored drawing was taken by me while it was living, is not now found in our collections, and I have not therefore been able to ascertain the character of the prælabial plate and thus assure myself whether the species are related to the Eriphidæ or not. It is very possible that the true place is after Ozinæ.

† Faun. Japon. 19.

‡ Near Pseudocarcinus, from which it differs in the ridge on the prælabial plate, as well as in its flatter form.

§ Crust. D'Orb. S. Am., 21.

G. 6. MELIA, *Latr.*—Carapax subquadratus, fere planus, fronte lato, oculis versus angulos insitis. Pedes toti graciles. Basis antennæ externæ cylindricus.

An genus sequens hîc pertinet?

ACANTHODES, *De Haan.**—Carapax angustus, *Pilumno* formâ affinis, spinis grandibus anticè armatus. Pedes spinosi.—Species *Acanthodes armatus* Haanii magnitudine portentosus.

3. ACTUMNINÆ.—Orbitâ *Ozinis* similis. Digiti instar cochlearis excavati.

G. ACTUMNUS, *Dana.*†—Carapax paulo transversus, valde convexus, antice lateraliterque curvatim declivis. Articulus antennæ externæ 1mus processum frontis attingens tantum.

4. ERIPHINÆ.—Orbita infra bene clausa, hiatu interno carens, articulo antennæ e orbitâ omnino excluso. Carapax sive paulo transversus sive subquadratus.

G. 1. RUPPELLIA, *Edw.*—Carapax latior. Antennæ pars mobilis externæ orbitâ paululum remota. Articulus maxillipedis externi 3tius paulo transversus.

G. 2. ERIPHIA, *Latr.*—Carapax angustus, convexus, fronte sæpius valde declivi. Antennæ pars mobilis externæ orbitâ longe remota. Articulus maxillipedis externi 3tius paulo transversus.

G. 3. DOMÆCIUS, *Souleyet.*‡—*Ruppelliæ* formâ antennisque externis affinis. Articulus maxillipedis externi 3tius valde transversus, brevissimus, epistomam tegens.

G. 4. TRAPEZIA, *Latr.*—Carapax subquadratus, planus, glaber, fronte horizontalis, leviter 6–8-dentatus, aut sinuosus, lateribus longitudinalis. Tarsi non unguiculati, minute spinulosi. Brachium ultra carapacem longe exsertum.

G. 5. TETRALIA, *Dana.*§—Carapax aspectu *Trapeziæ* affinis. Frons horizontalis, rectiusculus, subtilissimè denticulatus. Tarsi breviter unguiculati. Brachium ultra carapacem paulo exsertum.

G. 6. QUADRELLA, *Dana.*—Carapax subquadratus, paulo convexus, lævis, fronte horizontalis, 6-spinoso-dentatus. Tarsi unguiculati. Brachium ultra carapacem longe exsertum.

FAM. III. PORTUNIDÆ.

Pedes postici natatorii, tarso laminato. Ramus maxillipedis 1mi internus lobo interno instructus. Palatum colliculo utrinque sæpissime divisum. Corpus sive latum sive angustum, oculis sat brevibus.

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* Faun. Japon. 20.

† Very near Actæa, but the prælabial plate or palate is strongly divided by a ridge either side. Besides, the form is much narrower and more convex than in the Actææ, being subglobose above.

‡ Voy. of the Bonite; also, "Voy. au Pole Sud," under D'Urville, in the Astrolabe and Zélée, plate 6, figs. 3-7, by Hombron and Jacquinot.

§ This Journal, [2] xi, 223.

1. LUPINÆ.—Sutura sterni mediana segmenta tria intersecans. Palati colliculi prominentes.

1. *Pars antennæ externæ mobilis hiatu orbitæ non occlusa, orbitâ jacendo aptata.*

G. 1. Scylla, *De Haan.**—Valde latus et crassus, marginibus anterioribus simul sumtis bene arcuatus, antero-laterali longiore quam postero-lateralis. Pedes antici breviores, crassissimi, manu valde tumidâ, non angulatâ vel prismaticâ.

G. 2. Lupa, *Leach.*†—Valde latus, marginibus anterioribus totis simul sumtis bene arcuatus. Manus elongatè trigona aut prismatica, costata.

G. 3. Amphitrite, *De Haan*,‡ *Dana.*—Angustior. Margines frontalis antero-lateralisque angulo convenientes, antero-laterali raro breviore quam postero-lateralis. Manus elongata, prismatica. Basis antennæ externæ crassus, hiatu orbitæ parce angustior.

G. 4. Carupa, *Dana.*—Transversus. Margines frontalis antero-lateralisque angulo convenientes, fronte recto, emarginato. Basis antennæ externæ subcylindricus, hiatu orbitæ multo angustior.

2. *Pars antennæ externæ mobilis hiatu orbitæ omnino per basis processum occlusa, orbitâ plus minusve remota.*

G. 5. Thalamita, *Latr.*—Latus. Frons dimidio latitudinis carapacis longior; margo antero-lateralis longitudinalis. Articulus antennæ externæ 1mus prælongus, 2dus orbitâ remotissimus. Pedes antici longi, manu elongatâ.

G. 6. Charybdis, *De Haan*, *Dana.*§—Angustior. Frons dimidio latitudinis carapacis brevior; margo antero-lateralis obliquus. Articulus antennæ externæ 1mus paulo oblongus, 2dus orbitâ paulo remotus. Pedes antici longi, manu elongatâ.

G. 7. Lissocarcinus, *White.*‖—Suborbiculatus, lævis, subporcellanus. Articulus antennæ externæ 1mus brevis, fere longitudinalis, articulo sequente orbitâ parce remoto. Pedes nudi; antici breves, brachio ultra carapacem vix saliente, manu perbrevi.

2. ARENÆINÆ.—Sutura sterni mediana segmenta tria intersecans. Palatum colliculo utrinque non divisum. Ramus maxillipedis 1mi internus ad apicem late transversim triangulatus lineamque medianam fere attingens.

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* Faun. Japon. 11.

† *Neptunus*, *Pontus* and *Achelous* of De Haan, (Faun. Japon., 8, 9,) the distinctions between which genera appear not to be sustained.

‡ Faun. Japon. 8. Includes, as here adopted, the Lupa of De Haan, which division he restricts to the *Lupa forceps* (Edw. Crust. i, 456). The *Lupocyclus* of Adams and White, (Crust. Voy. Samarang, 47, pl. 12, f. 4,) appears to be identical with Amphitrite.

§ Fauna Japon. 10. Includes both *Charybdis* and *Oceanus* of De Haan, which divisions shade into one another by imperceptible gradations, and are not distinguished by any important characters. Corresponds to the "Thalamites Hexagonales" of Edwards.

‖ Crust. Voy. Samarang, 45. We have taken the generic characters from a species collected by us, in connection with the description by White.

G. Arenæus, *Dana.*—*Lupæ* affinis. Carapax valde latus, antice arcuatus. Pars antennæ externæ mobilis hiatu orbitæ insita. Manus prismatica.*

3. PORTUNINÆ.—Sutura sterni mediana segmenta duo intersecans. Colliculi palati sæpius obsoleti.

G. Portunus, *Fabr.*—Angustus, margine antero-laterali breviore quam postero-lateralis.

Fam. IV. PLATYONYCHIDÆ.

Pedes postici natatorii, tarso laminato. Ramus maxillipedis 1mi internus lobo interno non instructus. Palatum colliculo utrinque non divisum. Corpus angustum.

G. 1. Carcinus, *Leach.*†—Pedes postici male natatorii, tarso angustè lanceolato. Carapax parce transversus.

G. 2. Portumnus, *Leach.*—Pedes 5ti natatorii tantum, tarso lanceolato, acuto. Carapax non latior quam longior.

G. 3. Platyonychus, *Latr.*‡—Pedes 5ti natatorii tantum, tarso lato, elliptico. Carapax latior quam longior.

G. 4. Polybius, *Leach.*—Pedes 2di, 3tii, 4ti, 5ti toti natatorii, tarsis late lanceolatis.

Fam. V. PODOPHTHALMIDÆ.

Pedes postici natatorii, tarso laminato. Ramus maxillipedis 1mi internus lobo interno instructus. Corpus latum, antice valde transversum, orbitis oculisque longissimis.

G. Podophthalmus, *Lamarck.*

Legio II. TELPHUSINEA, vel CANCROIDEA GRAPSIDICA.

Fam. I. TELPHUSIDÆ.

Carapax subquadratus aut orbiculato-quadratus. Palatum colliculo utrinque sæpius divisum. [Species Eriphiis paulo affines.]

G. 1. Telphusa, *Latr.*—Articulus maxillipedis externi 3tius subquadratus, 2dus oblongus. Carapax subquadratus.

G. 2. Trichodactylus, *Latr.*—Articulus maxillipedis externi 3tius subtriangulatus, 2dus oblongus.

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* This genus is instituted for the Lupa cribraria, which differs from the other Lupas in the characters stated. This species occurs in the shallow waters off a sand beach.

† Xaiva of M'Leay (Smith's Illust. Zool. S. Africa) is described as near Carcinus. The narrow form is the same; the antero-lateral margin 1-dentate and shorter than the postero-lateral; the tarsus of the 5th pair of legs wider than in Carcinus; the 3d joint of the outer maxillipeds subquadrate and carinate at base, with the inner margin emarginated for the next joint just above its middle, a form which occurs in Platyonychus.

‡ *Anisopus* of De Haan, Faun. Japon.

G. 3. VALDIVIA, *White.**—Articulus maxillipedis externi 2dus brevior quam latior, 3tius longior quam latior.

G. 4. POTAMIA, *Latr.*—Articulus maxillipedis externi 3tius apice subtriangulatus anguloque apicali 4tum gerens. Palatum colliculo utrinque bene partitum.

An hîc pertinet genus *Galene* Haanii ?†

LEGIO III. CYCLINEA, VEL CANCROIDEA CORYSTIDICA.

Pedibus maxillipedeque 1mo CANCRIDIS affinis. Palatum colliculo utrinque non divisum. Antennæ externæ obsoletæ. Carapax angustus, suborbiculatus. Branchiæ numero septem.

G. 1. ACANTHOCYCLUS, *Lucas.*‡—Carapax orbiculatus. Pedes longitudine mediocres, tarso uncinato.

G. 2. CORYSTOIDES, *Lucas.*§—Carapax oblongus, ellipticus. Pedes longiores, tarso styliformi, longo. Antennæ internæ fossis carentes.

2. *Additional note to the Remarks on the Classification of the Maioidea;* by JAMES D. DANA.‖—The following genus by Kröyer¶ should be added to the synopsis given in the last number of this Journal. It appears to belong to the subfamily Inachinæ, and is classed near Inachus by its author. The species on which the genus is founded is the *Cancer phalangium* of Fabricius, Faun. Groenl. n. 214, and his *Cancer Opilio* in Det danske Vid. Selsk. Skr. nye Saml. iii, 180. It is from Greenland. Kröyer gives the following generic characters:—

G. CHIONŒCETES.—Cephalothorax depressus, subtriangularis, eadem fere longitudine ac latitudine, antice truncatus, fronte lata rostroque horizontali, bifido, brevissimo. Pedes 2di paris duplicem cephalothoracis longitudinem superantes, triplicem vero non attingentes; pedes 1mi paris 2dis tertiisque breviores, cephalothorace vero longiores (interdum duplo); chelis acuminatis, falcatis; *pedes 2di, 3tii, 4tique paris compressi*, 5ti paris subcylindrici. 3tius pedum maxillarium externorum articulus fere quadratus eadem pæne longitudine ac latitudine; 4tus articulus angulo interno tertii adnexus; oculi crassi, in orbitam retractiles; pars antennarum externarum terminalis mobilis brevissima. Abdomen sex constat articulis.—The name Chionœcetes is from *χιων*, *nix*, and *οικητης*, *incola*.

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* Ann. and Mag. Nat. Hist., xx, (1847,) 206.

† See page 127, where it is placed with the Ozinæ. The branchial cavity is very large, as in Potamia, and contains outside of the branchiæ a large open space. The shell of a specimen from the Sandwich Ids. closely like the *G. natalensis* of Krauss, has the appearance of a fresh-water or land species, the texture being less calcareous than in most marine species. The specimen was not collected by the writer, and its exact habitat is not known. Krauss's species occurred under stones on the shores at the mouth of a river in South Africa.

‡ Crust. D'Orbign. S. Am. 29, pl. 15,

§ Crust. D'Orbign. S. Am. 31, pl. 16.

‖ Last volume of this Journal, p. 425.

¶ Tidskrift, ii, 249.

3. *Microscopic examination of Soundings, made by the U. S. Coast Survey off the Atlantic Coast of the United States;* by Prof. J. W. BAILEY, (16 pp. 4to. with a plate; from vol. ii, of the Smithsonian Contributions to Knowledge.)—After special details with referenee to the character of the material in each case of sounding, Prof. Bailey gives the following very important statements as the general results of the examinations.

1st. The most remarkable fact determined by the examination of the above mentioned soundings is, that in all the deep soundings, from that of fifty-one fathoms S. E. of Montauk Point, to that of ninety fathoms S. E. of Cape Henlopen, there is a truly wonderful development of minute organic forms, consisting chiefly of Polythalamia, which occur in an abundance rivalling those vast accumulations of analogous forms constituting the marls under the city of Charleston, S. C.

2d. While there is a general resemblance between the species found in all the *deep* soundings above mentioned, the same species of Polythalamia occurring with few exceptions at each locality, yet each place has its predominant species; thus in the most southerly soundings, (H, No. 1, 90 fathoms,) there occurs a much greater number of Globigerina than in any of the others; while Textilaria atlantica, although present, is by no means so abundant as in "G, No. 8, 89 fathoms."

3d. Infusoria, as well as Polythalamia, occur in the deep soundings; but the infusoria are few in number, and consist of Coscinodisci, Gallionella sulcata, and other species, which probably swim freely in the ocean; while none of the littoral parasitic species, such as Achnanthes, Isthmia, Biddulphia, Striatella, and Synedra are found.

4th. It is worthy of notice that in the deep soundings not a single specimen was found of Polythalamia belonging to the Plicatilia of Ehrenberg, (Agathistiques of D'Orbigny,) while a number of these forms were found in the shallow soundings, and they are well known to occur in vast quantities around the shores of Florida and the West India Islands. This group of Polythalamia appears to have been created after the deposition of the chalk formation, in which no trace of such forms occurs, while they are very abundant in the tertiary deposites. Their entire absence in the deep soundings, where vast numbers of other Polythalamia occur, and their presence in littoral deposits, would seem to indicate that for their abundant development comparatively shallow seas are necessary; thus affording additional evidence of difference in the depths of the seas from which the cretaceous and tertiary beds were deposited.

5th. The deep soundings were all from localities which are more or less under the influence of the Gulf stream, and it is not improbable that the high temperature of the waters along the oceanic current may be the cause of immense development of organic life, making its path, as is shown by the soundings, a perfect milky way of Polythalamia forms. The deposits under Charleston may have been produced under the similar influence of an ancient gulf stream.

6th. From the presence of such great numbers of Polythalamia in the deep soundings, there results a very large proportion of calcareous matter, thus presenting a striking difference between them and the quartzose and felspathic sands nearer shore.

7th. The littoral sands obtained in shallow soundings at first view appear to afford little promise of affording any Infusoria. But notwithstanding their coarse, and, in some cases, even gravelly nature, they all yield by levigation a considerable number of silicious Infusoria, which in variety and abundance exceed those found in the deep soundings.

8th. None of the soundings present anything resembling the vast accumulations of Infusoria which occur in the Miocene infusorial marls of Virginia and Maryland: and, indeed, I have never found, even in estuaries, any recent deposit at all resembling the fossil ones, in abundance and variety of species, with the exception of the mud of a small creek opening into the Atlantic near Rockaway, Long Island.

9th. The occurrence of the pebble of limestone with encrinal plates in the gravel of F, No. 10, S. E. of Little Egg Harbor, is of some interest, as the nearest beds from which it could have come are the Silurian formations of Pennsylvania or northern New Jersey. It indicates a transportation of drift to a considerable distance sea-ward.

10th. In addition to the quartzose grains in the soundings, fragments of feldspar and hornblende (recognizable under the microscope by their cleavage planes and color) are found. The quartz, however, predominates, its grains being sharp and angular in the deep soundings, and often rounded or even polished in the shallow ones.

IV. Astronomy.

1. *On the new Ring of Saturn;* by W. C. Bond, Esq., Director of the Observatory of Harvard University, (Ast. Jour., vol. ii, No. 1, May, 1851.)—I had intended not to have made any communication on the subject of the new interior ring of *Saturn*, until an engraving had been prepared to exhibit its position and appearance. However, as I have been disappointed in this respect, and our continued observations having placed the fact of the existence of the ring beyond question, I will now ask permission to communicate some extracts from our note-book. [The engraving has since been made.]

The first diagram of the new interior ring of *Saturn* was made by G. P. Bond, on the night of the 11th of November, 1850. The memorandum in the note-book runs thus:—

"November 11th, $22^h\ 50^m$ sidereal time, ($=7^h\ 30^m$ mean solar time,) very good definition. We notice to-night, with full certainty, the filling up of light inside the inner edge of the inner ring of *Saturn;* also, what is very singular, where the ring crosses the ball from *c* to *d* (referring to a diagram), or *below* the edge, there is a dark band, no doubt the shadow of the ring. But there is *also a dark line* from *a* to *b*, or above the ring, very plainly to be seen, as there can be no question of the line where the ring crosses the ball.

"The light which fills the corners of the inner ring at *x* and *y* is suddenly terminated on the side towards the ball. The light does not arise, I think, from any optical cause, for I cannot see why the same appearance should not be visible on the outside of the ring, or, indeed, of any object which we look at. Am very confident of having seen to-night a second division of the ring, near the inner edge of the inner ring."

"November 15th, 7^h 30^m. Examined the new ring of *Saturn* with different powers, best definition with 400. New ring sharply defined; edge next the ball. W. C. Bond thinks he sees the new ring clear of connection with the old, but the side next the old ring is not so definite as next the planet, so that it is not certain whether the new is connected with the old ring or not. Where the dusky ring crosses *Saturn*, it appears a little wider at the outside of the ball than in the middle. Where the new ring crosses *Saturn*, it appears not so dark as the shadow of the ring below on the body of the planet."

"8 P. M. The best definition of *Saturn's* ring we have ever had. G. P. Bond examined with powers 140 and 400. Cannot be sure that the new ring is divided from the old one, but there can be no doubt that it exists; its inner edge is sharply defined. I did once or twice fancy, with the higher powers, that there was a division between the old and new rings. All the southern region of *Saturn* is dusky and striped with belts.

Outer diameter of outer ring, ...	$=43''\cdot9$
Inner diameter of inner ring, ...	$=29\ \cdot3$
Breadth of outer ring, ...	$=\ 2\ \cdot3$
Inner diameter of dusky ring, . . .	$=26\ \cdot3$
Distance of its inner edge from old ring, .	$=\ 1\ \cdot5$

"According to Encke's measures, *Astr. Nach.*, No. 338, the inner diameter of the inner ring should be, at the above date, about $29''\cdot8$; whereas, by the above measures, we make the inner diameter of the new ring to be only $26''\cdot3$."

Our observations, continued to the 7th of January, fully confirmed the deductions which we had drawn from those of the 11th and 15th of November.

The same appearances were noticed by the Rev. W. R. Dawes, at his Observatory, near Maidstone, in England, on the 25th and 29th of November, and subsequently by Mr. Lassell, of Starfield, near Liverpool. An account of their observations is given in the Royal Astronomical Society's *Notices* for January 10th, 1851.

2. *On the Total Eclipse of the Sun, of July* 28, 1851; by R. T. PAINE, Esq.—Although there will be many inducements for travellers from the United States to visit Europe this summer, it is believed there is no one stronger than the total eclipse of the Sun which will take place on Monday, the 28th of July, and which being visible over a great extent of the surface of the Earth, will be one of the most important that will happen for many years.

On this occasion a total or partial obscuration of the Sun may be seen throughout the greater part of North America, (Mexico and the southern extremity of Florida being excepted,) throughout Europe, in the western, northern, and northeastern parts of Asia, in the northern and northwestern parts of Africa, in Greenland, &c., whilst the line of the central and total eclipse will pass over 191 degrees of longitude, or from the vicinity of Sitka, the capital of the Russian settlements on our northwest coast, to the southeastern extremity of the Caspian sea.

But in no part of the United States will the eclipse be *total;* the greatest obscuration within our territory taking place at Cape Flattery,

in Oregon, at the entrance of the Straits of Fuca, where the Sun at $4^h\ 56^m$, A.M., or twenty-four minutes after it rises, will be about five-sixths ($10°\ 3'$) obscured on the north side. At San Francisco the greatest obscuration will take place before the Sun rises, but as the end of the eclipse may be seen, it is hoped it will be carefully observed not only there, but at every place in California and Oregon, where are suitable instruments, as a long time will elapse before another as favorable an opportunity offers, for the determination of the longitude.

Indeed, a *total* eclipse of the Sun at any particular place so seldom occurs, that but a small part of those inhabitants of the earth who remain stationary, ever have an opportunity of beholding this, the most sublime of all phenomena. In April, 1715, the Sun was entirely hidden by the Moon at London, and again in May, 1724, at Paris, but in the course of the long interval between those years and 1901, and perhaps much longer, the shadow of the Moon has not again passed, and will not, over either of those cities. The only total eclipse that has happened in Boston, since its settlement in 1630, as is believed, was that which took place under such very favorable circumstances, on June 16th, 1806, and by the list of eclipses from 1824 to 1901, originally published in the Columbian Sentinel, and afterwards in an abridged form in the American Almanac for 1831, it appears that there will not be any other, certainly within the present century; moreover, it is very probable, that there are many places in this country, at which there has not been, since their settlement by Europeans, even one.

It also appears, by the list above referred to, that in the course of the seventy-five years between 1826 and 1901, the shadow of the Moon passes but three times over any part of our widely extended Atlantic coast, viz. on November 30th, 1834, over a small part of Georgia and South Carolina; on August 7th, 1869, of North Carolina and Virginia, and on May 28th, 1900, over part of Virginia. Annular eclipses, it is true, occur more frequently, as those of April, 1791, and February, 1831, were, and those of May 26th, 1854, and September 29th, 1875, will be, visible in Massachusetts, or four in about a century and a quarter; but these eclipses, although beautiful, have little of the sublimity that attends a total obscuration.

Rare therefore, as is, in general, the occurrence of a central eclipse at any particular place, it occasionally happens, that some places are, in this respect, especially favored. Thus, the eclipse of July 8th, 1842 was, and that of the present year will be, central in Poland in lat. $50°\ 36'{\cdot}7$ N. long. $27°\ 5'{\cdot}5$ East, so that the inhabitants of that spot will have an opportunity of beholding two total eclipses of the Sun in the course of nine years. In this country the central path of February 12th, 1831, was crossed in Alabama by that of November 30th, 1834, and in Virginia by that of September 18th, 1838, and in 1853 the two eclipses of June 6th and November 30th, will both be central in the Pacific Ocean in long. about 125° West, lat. 2° South; these are, however, but exceptions to the general rule, and the places thus favored are nearly points on the surface of the Earth.

The width of the shadow of the Moon on the 28th of July next, will vary as usual whilst passing over the Earth, but in Greenland, Norway,

Sweden and Prussia it will be about 140 geographical miles. If, therefore, the central path given below, be carefully marked on a good map, and a line be drawn parallel thereto to the north and another to the south, at the distance of seventy miles or a little less therefrom, the places at which the eclipse will be total will be easily seen, there being of course some doubt as to those situated like Elsineur, just within the edge of the shadow, as a small error in the Moon's tabular latitude is not uncommon. Within the lines thus drawn are included in America several of the Russian settlements southeast of Sitka, part of British Oregon, two of the forts of the Hudson's Bay Company on the Great Slave Lake, the winter harbor of Capt. Ross in 1830, and of Capt. Parry in 1822, the Northern part of the Island of Disco, in Baffin's Bay and several of the Danish villages on the Western coast of Greenland; and in Europe the Northern part of Iceland, the astronomical observatories at Christiana, Koeningsburg, Warsaw, and Nicolaef, also the cities of Bergen, Gottenburg, Carlscrona, Calmar, Frederickshall, Jorkoping, Dantzic, Elbing, Pillau, Jitomir and Cherson; and in Asia, Tifflis and Bakou, between the Black and Caspian, besides many others of less note; but Sitka, and Stockholm, Copenhagen and Odessa are not included within these limits, the two former being situated a little too far to the north, and the two latter to the south.

The most favorable of all situations for observing the eclipse will be where central, on the western coast of Greenland, in the southern part of Norway, Sweden, and of the Island of Oland, and in Prussia, on the Baltic, between Dantzic and Koeningsburg; as the Moon being there quite high the duration of total darkness will be greater than where nearer the horizon. Thus where central, in the vicinity of Port Stewart, the Sun being low in the east, and of Tefflis, in the west, the duration of the total obscuration will be 2m. 26sec. and 2m. 31sec., at Fort Providence 2m. 49sec., in Greenland 3m. 49sec., near Bergen 3m. 38sec., near Pillau 3m. 20sec., and where central, in the vicinity of Nicolaef 2m. 55sec.

Although, as is above remarked, the diameter of the perfect shadow on the Earth, is only about 140 geographical miles, the extent of the partial shadow is comparatively very great. Indeed, if we reduce the time of the end of the eclipse at Sitka, and of the beginning at Warsaw, to a common meridian, as that of Greenwich, it will be seen that the latter precedes the former by one minute, so that although these places differ 156 degrees in longitude and their distance from each other is more than 5400 geographical, or 6200 English miles, the eclipse will begin at Warsaw on the right side of the Sun, 61 seconds before it will end at Sitka, on the left; the Sun, throughout the intervening space, being more or less obscured.

The elements of the Sun and Moon, for the following computations were deduced from the English Nautical Almanac, but their diameters and the parallax of the latter, were increased by the quantities recently recommended by Prof. Airy as the result of twelve years observations (1836 to 1847) at the Royal Observatory at Greenwich. The ellipticity of the earth being considered to be $\frac{1}{300}$th.

Path of the Central Eclipse, or of the centre of the shadow of the Moon over the Earth, on Monday, July 28th, 1851.

MEAN TIME AT GREENWICH.

Eclipse Central at	In Latitude.	In Longitude.	Eclipse Central at	In Latitude.	In Longitude.
h. m. sec.	° ′	° ′	h. m. sec.	° ′	° ′
1 25 46½	53 42·7 N.	137 47·6 W.	2 53 0	62 58·9 N.	0 0·6 E.
25 48	54 12·7	136 31·2	54 0	44·4	0 50·8
26 0	55 19·2	133 40·8	55 0	23·6	1 40·5
26 30	56 38·8	130 13·9	56 0	5·6	2 29·8
27 0	57 32·7	127 51·3	57 0	61 47·3	3 18·6
28 0	58 53·4	124 12·0	58 0	28·8	4 7·0
30 0	60 50·3	118 37·2	59 0	10·1	4 55·1
32 30	62 39·3	112 56·9	3 0 0	60 51·1	5 42·8
35 0	64 6·3	107 59·7	1 0	31·9	6 30·3
37 30	65 19·0	103 19·2	2 0	12·4	7 17·5
40 0	66 21·1	98 52·4	3 0	59 52·7	8 4·4
42 30	67 14·7	94 32·7	4 0	32·8	8 51·1
45 0	68 0·9	90 17·4	5 0	12·6	9 37·7
47 30	40·6	86 4·5	6 0	58 52·1	10 24·2
50 0	69 14·5	81 53·0	7 0	31·4	11 10·5
52 30	42·9	77 42·8	8 0	10·4	11 56·8
55 0	70 6·2	73 33·8	9 0	57 49·1	12 43·0
57 30	24·6	69 26·2	10 0	27·5	13 29·3
2 0 0	38·3	65 20·5	11 0	5·6	14 15·7
2 30	47·5	61 17·3	12 0	56 43·4	15 2·2
5 0	52·5	57 17·4	13 0	20·8	15 48·8
* 7 0	53·6	54 8·4	14 0	55 57·9	16 35·6
7 30	53·4	53 21·6	15 0	34·7	17 22·8
10 0	50·5	49 30·7	16 0	11·0	18 10·4
12 30	43·9	45 45·2	17 0	54 47·0	18 58·3
15 0	33·9	42 5·7	18 0	22·6	19 46·6
17 30	20·6	38 32·8	19 0	53 57·8	20 35·5
20 0	70 4·3	35 6·9	20 0	32·5	21 25·0
**21 2½	69 56·7	33 42·9	21 0	6·6	22 15·3
22 30	45·1	31 48·0	22 0	52 40·1	23 6·4
25 0	23·3	28 36·3	23 0	13·2	23 58·5
27 30	68 59·0	25 31·7	24 0	51 45·7	24 51·7
30 0	32·3	22 34·2	25 0	17·6	25 46·3
31 0	21·0	21 25·1	26 0	50 48·7	26 42·2
32 0	9·4	20 17·2	27 0	18·9	27 39·7
33 0	67 57·4	19 10·3	28 0	49 48·2	28 39·2
34 0	45·1	18 4·4	29 0	16·5	29 40·9
35 0	32·5	16 59·5	30 0	48 43·6	30 45·2
36 0	19·6	15 55·6	31 0	9·4	31 52·7
37 0	6·4	14 52·8	32 0	47 33·6	33 3·9
38 0	66 52·9	13 50·9	33 0	46 55·9	34 19·5
39 0	39·1	12 49·9	34 0	15·9	35 40·8
40 0	25·1	11 49·8	35 0	45 33·2	37 9·6
41 0	10·8	10 50·6	36 0	44 46·5	38 48·1
42 0	65 56·2	9 52·3	36 30	21·2	39 42·0
43 0	41·3	8 54·8	37 0	43 54·4	40 40·8
44 0	26·2	7 58·1	37 30	25·5	41 45·2
45 0	10·8	7 2·2	38 0	42 53·7	42 56·6
46 0	64 55·1	6 7·0	38 30	17·9	44 19·0
47 0	39·2	5 12·5	39 0	41 35·7	45 58·9
48 0	23·1	4 18·8	39 30	40 40·0	48 16·1
49 0	6·7	3 25·7	39 40	13·9	49 22·6
50 0	63 50·1	2 33·2	39 50	39 33·7	51 7·8
51 0	33·3	1 41·4	39 53	38 59·1	52 41·9
52 0	16·2	0 50·1			

* Greatest north latitude of the central path. ** On the meridian of the place.
Duration of the central eclipse on the earth 2h. 14m. 6½sec.

The beginning and end, &c. of the eclipse at the following places are expressed in mean and civil time of each particular place. The angles of the points on the Sun's disc, at which the obscuration will begin and end are counted from the vertex or highest point of the Sun towards the right hand, as seen through a telescope that does *not* invert; for an astronomical telescope, 180 degrees should be added thereto.

The Sun will rise at Sitka and Port Stewart at 3h. 56m. and 4h. 3m. and will set at Tifflis at 7h. 20m. The obscuration at the Observatory at Cambridge will be on the northern, and at Sitka on the southern limb of the Sun.

	Sitka.	Cambridge Observatory.
Latitude,	57° 2′ 54″	42° 22′ 48″
Longitude West,	135 17 12	71 8 2
	h. m. sec.	h. m. sec.
Beginning of the eclipse,	— — — A.M.	7 48 10 A.M.
Greatest obscuration,	4 27 36	8 37 51
End of the eclipse,	5 19 38	9 31 18
Duration of the eclipse,	— — —	1 43 8
Digits eclipsed,	11° 51′ —	3° 47′
Angle of beginning,	— — —	350°·9
" end,	231°·4 —	262°·1

	Port Stewart.	F. Providence.	Niakernak.
Latitude,	55° 38′ 18″	62° 17′ 19″	70° 47′ 0″
Longitude West,	131 47	114 9 28	53 23 36
	h. m. sec.	h. m. sec.	h. m. sec.
Eclipse begins,	— — — A.M.	5 1 2 A.M.	9 29 56 A.M.
Total eclipse begins,	4 37 26	5 53 54	10 32 1
Least distance of centre,	4 38 35	55 22	33 50
Total eclipse ends,	4 39 45	56 42	35 39
Eclipse ends,	5 31 11	6 52 18	11 38 45
Duration of total eclipse,	2 19	2 48	3 38
Duration of whole do.	— — —	1 52 16	2 8 49
Angle of beg. of eclipse,	— — —	58° ·7	67°·5
do. of end of eclipse,	232°·1	235°·9	257°·5
At the least distance of centres,	Moon N. 11″·96 diff. S. D. 45″·53	Moon south 0″·43 diff. S. D. 49″·05	Moon north 4″·43 diff. S. D. 55″·06

	Bergen.	Christiana.	Gottenburg.
Latitude,	60° 24′ 0″	59° 54′ 42″	57° 42′ 4″
Longitude East,	5 18 3	10 43 31	11 56 39
	h. m. sec.	h. m. sec.	h. m. sec.
Eclipse begins,	2 15 45 P.M.	2 42 35 P.M.	2 51 48 P.M.
Total eclipse begins,	3 19 59	3 45 54	3 54 54
Least distance of centres,	21 42	47 15	56 36
Total eclipse ends,	23 24	48 37	58 18
Eclipse ends,	4 24 6	4 48 18	4 57 26
Duration total eclipse,	3 25	2 43	3 24
" whole do.	2 8 21	2 5 43	2 5 38
Angle of beg'g. of eclipse,	97°·5	102°·3	103°·8
" of end,	287°·3	287°·4	291°·1
At the least distance of centres,	Moon N'rth 18″·88 diff. S. D. 55″·24	South 34″·70 54″·58	North 13″·67 54″·50

	Dantzic.				Pillau.				Koningsburg.			
Latitude North, ...	54°	24′	15″		54°	33′	39″		54°	42′	50″	
Longitude East, ...	18	40	15		19	52	30		20	30	6	
	h.	m.	sec.		h.	m.	sec.		h.	m.	sec.	
Eclipse begins, ...	3	29	7	P.M.	3	34	28	P.M.	3	37	7	P.M.
Total eclipse begins, ...	4	30	37		4	35	34		4	38	7	
Least distance of centres,		32	14			37	13			39	39	
Total eclipse ends, ...		33	51			38	52			41	10	
Eclipse ends, ...	5	31	10		5	35	49		5	38	4	
Duration total eclipse, ...		3	14			3	18			3	3	
" whole "	2	2	3		2	1	21		2	0	57	
Angle of beginning, ...		110°·0				111°·0				111°·4		
" of end, ...		294°·6				293°·6				293°·1		
At the least distance of centres, ...	Moon N'rth 14″·58 diff. S. D. 53″·43				South 6″·80 diff. S. D. 53″·28				South 20″·02 diff. S. D. 53″·13			

	Warsaw.				Nicolaef.				Tiflis.			
Latitude, ...	52°	13′	5″		46°	58′	21″		41°	41′	4″	
Longitude East, ...	21	2	9		31	58	48		44	50	40	
	h.	m.	sec.		h.	m.	sec.		h.	m.	sec.	
Eclipse begins, ...	3	43	54	P.M.	4	42	13	P.M.	5	44	31	P.M.
Total eclipse begins, ...	4	45	25		5	39	44		6	37	21	
Least distance of centres,		46	20			40	50			38	35	
Total eclipse ends, ...		47	16			41	56			39	48	
Eclipse ends, ...	5	44	27		6	35	19		—	—	—	
Duration total eclipse, ...		1	51			2	12			2	27	
" whole do., ...	2	0	33		1	53	6		—	—	—	
Angle of beginning, ...		112°·5				120°·5				126°·2		
" of end, ...		297°·2				300°·4			—	—	—	
At least distance of centres, ...	Moon N'rth 43″·58 diff. S. D. 52″·93				North 32″·97 diff. S. D. 50″·39				North 11″·90 diff. S. D. 47″·02			

At Carlscrona, lat. 56° 9′ 31″, lon. 15° 35′ 13″ E., the apparent North latitude of the Moon at 4h. 15m. 35sec. will be 8″·41, and the eclipse will be total from 4h. 13m. 51sec. to 4h. 17m. 16sec.

At Elsineur, lat. 56° 2′ 20″, lon. 12° 37′ 30″ E., the least distance of the centres (53″·84) will take place at 4h. 2m. 34sec., and as the difference of the semi-diameters is 54″·45, the eclipse by computation will be total there.

At Copenhagen, in lat. 55° 40′ 53″, lon. 12° 34′ 57″ E., the least distance (65″·28) will take place at 4h. 3m. 1sec., and the magnitude of the obscuration will be 11° 56′ on the north limb of the Sun.—*Boston Daily Advertiser.*

Boston, March 26th, 1851.

V. Miscellaneous Intelligence.

1. *Electro-magnetic Locomotive*, (From the National Intelligencer of May 3, 1851.)—We lay before our readers a statement from Professor Page respecting the *Electro-magnetic Locomotive;* and when we regard the fact that the highest power ever attained before his experiments was less than half a horse power, and that costing probably one hundred times as much as it does under this new mode of its application, we cannot be indifferent to so great a result, and the high promises with which it seems to be fraught:

Messrs. Editors:—The electro-magnetic locomotive made a very favorable trip on Tuesday last, more especially when it is taken into the account that we were constrained to make this trial with only one-

half (or even a little less,) of the power the engines and battery are capable of yielding. Each engine, calculated upon the basis of my stationary engine, ought to give at the lowest estimate 12 horse power, which would make the locomotive 24 horse power. The actual power I have not been able to ascertain; but the following data may serve to give some idea of its power. The locomotive, with the battery fully charged, weighs ten and a half tons. With the seven passengers taken on the trip to and from Bladensburg the weight was eleven tons. Under the most favorable arrangements *eight pounds* are required to start a ton on a perfectly level rail, and seven pounds will barely keep a ton in motion. Ordinarily, upon railroads the allowance is ten pounds to a ton, but this applies only to cars unincumbered by machinery. The friction of locomotive machinery renders its draught far greater, and can only be accurately ascertained by experiment in each case. The magnetic locomotive, the first of its kind ever made, is imperfect, and, from the newness and stiffness of all the work, it runs exceedingly hard. We will take 200 pounds, which is below its actual power required to keep it in motion on a level portion of the road. A horse power upon the usual estimate is 150 pounds $2\frac{1}{2}$ miles an hour, or 375 pounds 1 mile an hour. The speed of the magnetic locomotive is, we will say, 15 miles an hour on a level road, (it has in fact made more,) and its traction 200 pounds. We have then 375 pounds 1 mile an hour for one horse, and 200 pounds 15 miles an hour for the locomotive, which gives *eight* horse power. But the engine has more than this. It has greater power at a slow speed, and must have, by all reasonable estimates, twelve horse power; which, as I said before, is about one-half its proper capacity. One of the most serious defects arises from a want of insulation in the helices. After the engine was placed on the road it was found neccessary to throw out of action five of the helices, and these at the most important point in the stroke. This difficulty could not be remedied without taking both engines entirely out—an undertaking for which I had neither time nor means, as the track with which we are now accommodated is soon to be filled up for the purposes of the Railroad company. Another serious difficulty encountered was the breaking of the porous cells in the battery, causing a mixture of the two acids, and the interception of a large portion of the power. I had great difficulty in procuring suitable porous cells, and the manufacture of such as I needed was, after a great expense, given up by two of the best pottery establishments in the country as a thing impracticable. It was, however, accomplished through the ingenuity of Mr. Ari Davis, my engineer, but they were made of a weak clay, and have now, from frequent use, become so much impaired as to break from the slightest causes. Before we started two of them broke, and the defect was only partially repaired. Not far from Bladensburg two more gave way, and detracted at once greatly from our working power. On our return, about two miles from Bladensburg, three more gave way, and we were reduced to at least one-half of our power. The running time from Washington to Bladensburg was thirty-nine minutes. We were stopped on the way five times, or we should have probably made the run in less than thirty minutes. Going and coming there were seven stops and three delays—that is, the engine

was backed three times, but without entirely losing headway. It is a very important and interesting feature of this engine, which I demonstrated some years since, that the reversing power is greater than the propelling power; it is nearly twice as great. When the engine is reversed, the magnetic electric induction is in favor of the battery current, and augments its effects. The defect of the cells is easily remedied. The trouble growing out of the oscillating motion of the car can all be obviated by using rotary instead of reciprocating engines. The greatest speed attained on our last trip was about nineteen miles an hour, and about seven more than in any former experiment.

Washington, May 1, 1851. CHARLES G. PAGE.

2. *Meeting of the American Association for the Advancement of Science at Cincinnati.*—The Cincinnati meeting of the Association commenced on Monday, May 5th, and continued through the week. The attendance was large, and the papers presented numerous and important, as will be seen from the following catalogue. The department which had the most attention was that of Geology, while at the preceding meeting at New Haven there were very few papers on this subject. The papers read are as follows:—

ASTRONOMY, MATHEMATICS, PHYSICS, &c.

On the limit of perceptibility of a direct and reflected sound. By Prof. HENRY, of the Smithsonian Institution.

On an Apparatus for determining Altitudes by means of the Boiling Point. By Prof. J. HENRY.

On the Constitution of Saturn's Ring. By Prof. PEIRCE, of Harvard.

Report of the Committee upon Prof. MITCHEL's System of Astronomical Observations. By Prof. PEIRCE, Chairman of the Committee.

On a Method of determining the Velocity of Sound by Coincidences. By Prof. A. D. BACHE, Superintendent of the U. S. Coast Survey.

Notes on the Zenith Telescope in determining latitudes in the Coast Survey, by Talcott's Method, and on the reduction of the Observations. By Prof. A. D. BACHE.

Current Chart of New York Bay, from Observations in the Coast Survey. By Prof. A. D. BACHE.

Comparison of Curves showing the hourly changes of Magnetic Declination at Philadelphia, Toronto, and Hobartown. By Prof. A. D. BACHE.

On a Modification of Apparatus for the Registration of Time, for Astronomical Purposes by means of Electricity. By W. WURDEMANN, of Washington City.

On the Motion of the Sun about the Centre of Gravity of the Solar System. By Prof. GEO. W. COAKLEY, of St. James.

On a new method of geometrically constructing the Integration by Quadratures. By Rev. TH. HILL.

On the Longitude of the Cincinnati Observatory by Telegraphic Operations, in connection with the U. S. Coast Survey. By Prof. O. M. MITCHEL, Director of the Cincinnati Observatory.

On a new Theory of Statements by Proportions. By Prof. THOMAS RAINEY, of Cincinnati.

On a method of distinguishing between Bi-axial and Uni-axial Crystals when in thin plates, and the results of the examination of several supposed Uni-axial Micas. By WILLIAM P. BLAKE, of New York.

On the Orbital courses of Storms, as opposed to the received hypotheses of general winds, founded on the alleged influence of equatorial temperature. By W. C. REDFIELD, Esq., of New York.

On the Mean Temperature of Cincinnati, and the Methods of calculating Mean Temperatures. By Dr. JOSEPH RAY, of Cincinnati.

On the Effects of the Areas of Oceanic Temperatures on Meteorological Phenomena. By Capt. C. WILKES.

On a new Form of Railroad Curves. By Rev. TH. HILL.

On a curious fact in relation to a Turbine Wheel. By Mr. CHASE, of Mass.

Chemistry and Mineralogy.

On the Detection of Organic Miasm in the Air. By George C. Schaeffer, Prof. of Chemistry and Natural Philosophy, Centre College, Danville, Ky.

On the Cause of Saltpetre Explosions. By George C. Schaeffer, Danville, Ky.

On the Chemical Effects produced by feeble electrical currents. By Daniel Vaughan.

On the existence of Phosphorus in certain Des Moines Iron Stones. By Doct. D. D. Owen, U. S. Geologist of the Chippewa Land District.

On the Association of certain Minerals in Northern New York. By Franklin B. Hough, M.D.

Geology.

Results of an Exploration of the Coral Reefs of Florida, in connection with the U. S. Coast Survey. By Prof. L. Agassiz, of Harvard.

On the Post-Permian date of the Red Sandstone Rocks of New Jersey, and the Connecticut Valley, as shown by fossil remains. By W. C. Redfield, of New York.

On the Fossil Rain-marks in the Red Sandstone Rocks of New Jersey and Connecticut, and their authentic character. By W. C. Redfield, of New York.

Parallelism of the Palæozoic Rocks of New York with those of the Western States, and of all these with the Palæozoic strata of Europe. By Prof. James Hall,

On the Silurian Rocks of the Lake Superior Land District. By Prof. James Hall, Palæontologist of the Survey.

On the Number and Distribution of Fossil Specimens in the Palæozoic Rocks of Iowa, Wisconsin, and Minnesota. By Drs. D. D. Owen, and B. Schumard, of New Harmony, Ind.

On the Palæontology of the Lowest Sandstones of Wisconsin, Iowa, and Minnesota. By D. D. Owen, M.D.

Abstract of an Introduction to the final Report on the Geological Surveys made in Wisconsin, Iowa, and Minnesota, in the years 1847–8–9 and 50, containg a Synopsis of the Geological features of the country. By D. D. Owen.

On the Azoic System of Lake Superior. By Messrs. Foster and Whitney, U. S. Geologists of the Lake Superior Land District.

On the age of the Sandstone of Lake Superior, with a description of the phenomena of the associated igneous rocks. By Messrs. Foster and Whitney.

On the different Systems of Elevation which have given configuration to North America. By J. W. Foster, U. S. Geologist for the Land District of Lake Superior.

On the Superficial Deposits of the North-West. By Charles Whittlesey, of the U. S. Geological Survey of Lake Superior.

On the Equivalency of the Rocks of North Eastern Ohio and the Portage, Chemung and Hamilton Rocks of New York. By Charles Whittlesey, Esq.

On the Goniatite Limestone of the Black Slate of Rockford, Jackson County, Indiana. By D. Christy, of Oxford, Ohio.

On Quartz Pebbles in the Sandstone Conglomerate, and Reasons for rejecting the Theory of Water Detrition. By Prof. J. Brainerd, of Cleveland.

Notes on the Survey of the Boundary betweeen the United States and Mexico. By Maj. W. W. Emory.

On the law of deposit by the flood tide. By Lieut. Charles H. Davis, U.S.N., Superintendent of the American Nautical Almanac.

Report of the Committee appointed to memorialize the Legislature of Pennsylvania in reference to the publication of the final geological report of that State. By Solomon W. Roberts, Civil Engineer.

Zoology and Botany.

On the limits of the class of Polypi and the rank and succession of their chief natural divisions. By Prof. L. Agassiz, of Harvard.

On some Points of the Structure and Reproduction of Physalia. By Prof. L. Agassiz.

On the special Homologies of the true Star Fishes and Crinoids. By Prof. L. Agassiz.

On the special Homologies of Acephala. By Prof. L. Agassiz.

Report on the Vertebrate fossils exhibited before the Association. By Prof. L. Agassiz.

On the structure and reproduction of Porites. By Prof. L. AGASSIZ.

On the Holothuriæ of the Atlantic Coast of the United States. By L. F. POURTALES, of Washington.

On the Gephyrea of the Atlantic Coast of the United States. By L. F. POURTALES.

On a specimen of the Fossil Ox, found in Trumbull Co., Ohio. By Prof. SAMUEL ST. JOHN, of Cleveland.

Remarks on the sexes and habits of some of the acephalous Bivalve Mollusca. By Dr. J. P. KIRTLAND.

On the Distribution of Crinoidea in the Western States. By Dr. L. P. YANDELL, of Louisville.

On the Geographical Distribution of some species of Terrestrial and Fluviatile Shells. By Dr. J. S. NEWBERRY.

Report on the Invertebrate fossils exhibited before the Association. By Prof. J. HALL.

On certain Human and other bones from a cave near Elyria, Ohio. By CHAS. WHITTLESEY, Jr., of Cleveland.

On the Flora of Texas. By Dr. GEO. ENGELMANN, of St. Louis.

On the History and Nomenclature of some cultivated Vegetables. By Dr. T. W. HARRIS, of Harvard College.

3. *Gold in Arkansas*, (from the N. O. Bee.)—Some weeks ago we mentioned the fact that Mr. Snell, an accomplished mineralogist of our city, had discovered, in the course of scientific exploration in certain portions of Arkansas, unmistakeable indications of an auriferous deposit. Mr. S. had in one instance picked out of the crevice of a rock a piece weighing about an ounce, in which gold was abundantly intermixed with the quartz, in the usual mechanical combination in which the two are found. Although this was but an isolated discovery, Mr. Snell predicted, with a confidence based upon the geological peculiarity of the country, that gold existed there probably in sufficient quantities to remunerate labor and enterprise. His prediction has been speedily verified.

Yesterday we had the pleasure of examining three very handsome specimens of Arkansas gold, as genuine as any that ever glittered amidst the sands of California. They were found in the bed of White river, some miles above Batesville, and in a range of rocky country, precisely similar in feature to the region where Mr. Snell obtained his specimen. The largest lump was a mass of quartz of a dirty white color, profusely penetrated by the precious metal, and in some places so completely mingled with it, that the gold seemed like an integral part of the rock. The other samples were smaller, and presented nearly a similar appearance. We presume that in the three pieces there could hardly have been less than five or six ounces of pure gold. These products of the mineral wealth of Arkansas were sent to Mr. Snell to be assayed.

4. *Rise and Fall of Lake Erie*, (from the Buffalo Advertiser of April 16.)—Various papers have recently alluded to the rise and fall of Lake Erie, maintaining that it is periodical every few years. The following memorandum, made by one of our intelligent citizens, who has carefully watched the rise and fall since 1839, settles the matter most conclusively.

The Toledo *Blade* represents Lake Erie as falling, and that there is a periodical rise and fall of its surface, once in twelve or fourteen years.

Some of your readers may be pleased to get *facts* from authentic records.

The highest state of the lake in calm weather ever recorded, was in June, 1838, when it stood 5 feet 4 inches above the zero at Buffalo:

	ft.	in.		ft.	in.
1839, May 11, it stood,	3	5	1846, May 16,	2	
1840, May 14,	3	9	1847, May 16,	2	6
1841, May 18,	3	1	1848, May 1,	2	2
1842, May 5,	3	7	1846, May 19,	3	1
1843, May 15, (supposed,)	2	8	1850, May 12,	2	8
1844, May 12,	2	11	1851, April 8,	2	11
1845, May 15,	3				

The very highest on record was by the tempest in the night of the 18–19 October, '44, at which time it rose to *thirteen feet eight inches* above the zero at Buffalo.

The very lowest on record, caused by a strong gale from northeast, was in the afternoon of the 18th of April, 1848, when it fell to 22 inches below zero.

The idea of a periodical rise and fall, once in a few years, is repudiated by exact observers.

The general observation is, that the surface reaches its maximum for the year, about the first of July, then falls a little to about the first of October, then rises slowly to about the first of December, then falls rapidly to about the tenth of February, then rises (in March very rapidly) and continues to rise until July.

OBITUARY.

Dr. S. G. Morton.—With sadness we record the death of an eminent man from the ranks of American science, Dr. Samuel George Morton of Philadelphia. He died on the 15th of May last, in his 53d year. The following paragraphs from obituary notices published upon his decease, but imperfectly express our own high estimate of his learning and his many personal excellencies.

Dr. Morton was a native of Philadelphia, born in connection, we believe, with the Society of Friends, which has given to it so many citizens distinguished in the walks of science. Adopting the medical profession, which he studied under the auspices of the late Dr. Isaac Parrish, he received the honors of the doctorate from the University of Pennsylvania, but afterwards proceeded to Edinburg, where he graduated again with distinction, highly esteemed for his literary abilities, as well as his professional proficiency. Young, ardent, with the enthusiasm of a poetical temperament—for poetry was his first ambition—but a manly sense and purpose that enabled him to postpone the imaginative to the solid and useful, he made the tour of Europe, shook hands with warm friends and relatives in Ireland, the land of his ancestors, where strong inducements were offered to retain him, and returned to his native country, and to his native city, here to commence a career which, even at that early moment, he had marked out, and to build up for himself a name not likely soon to be forgotten. It is scarce necessary for us to refer to the success of his professional or merely medical career. That was always great. For years, no physician in Phil-

adelphia could boast a larger, few an equal practice. His claims to distinction, in this capacity, were proved by his well known work on Consumption and other valuable publications, as well as by his lectures at the Philadelphia Hospital, Pennsylvania College, and other medical institutions with which he was at different times connected.

One would suppose that with the burthen of his heavy practice, and all the addition of these laborious collaterals pressing upon him, he could find but little leisure for other pursuits, and indulge but small hope of acquiring fame in a different path. His history is an example of what men *can* do, even under adverse circumstances, who are patient, who are resolute, who are industrious, who are wise, who are true to themselves and sufficient to themselves. Ever calm, but ever active, always prepared for the exigencies of his business duties, and ever ready to devote to profitable use the scanty intervals of leisure which those duties allowed him, he found time for continual participation in scientific affairs, and in the proceedings of the Academy of Natural Sciences, of which he was for thirty years a member—and for many years its Vice President and President; and, what is more, with the additional incumbrance of this general scientific participation, he found time also to produce those great works, the *Crania Americana* and *Crania Ægyptiaca*, which immediately placed him in the front rank of archæologists and ethnographers throughout the world. The appearance of the first named of these volumes established an era; it opened a new department of research; it created a new science—one that has done more for the true exposition of human history, the interpretation of the mysteries of race differences and race affinities—far more than any thing ever previously effected by the pen of the annalist or the wand of science. Few scientific works ever produced a stronger or more durable impression on the philosophic mind, or have had a more powerful effect in directing the course of future investigations.

But we have no space to write the history or attempt the eulogium of Dr. Morton. That task will fall to more competent hands; though it could be undertaken by none who knew him better or prized him more. It will be all the more justly executed where there is a less lively sensibility or less oppressive appreciation of his loss. Let us say of him, only, that he was a good, as well as great man; estimable in all his relations; respectable in all he thought and did; a man of pure heart and blameless life; a faithful physician; a kind friend; a loving husband and father; a gentle companion; an exemplary citizen.

It is only at the hour of his death, that many, who knew Dr. Morton well, will be conscious that a great man has been taken away, and a light quenched which has long shed a common lustre upon the country and the world.—*North American*, Philadelphia.

Few men more respected and beloved have been taken from us than Dr. Samuel George Morton, and few more respected and beloved remain. It is not only in the domestic and social relations, as husband, brother, friend and neighbor, that his place cannot be supplied: but his position in the profession, and as a man of science, it will be equally difficult to fill. His whole character was marked by singular proprie-

ties. As a man and a gentleman he was equally amiable and accomplished, simple and dignified. Few men of so extended reputation appeared so unconcious of it; few men accomplished so much with so little apparent effort; few combined more varied powers, or a greater variety of excellent traits, all founded on solid worth. Few men brought a happier countenance into a sick chamber, or inspired more confidence while there, or commanded more respect in consultation. Few understood better those nicer delicacies and discriminating proprieties which should govern a man in those peculiar trials which the profession sometimes presents.—*Evening Bulletin*, Philadelphia.

Seldom has our city been more deeply moved in its literary and professional ranks, by the ravages of death, than during the past week, in the comparatively sudden and unexpected decease of Dr. Samuel George Morton. After a short sickness of about four days, disease had done its perfect work. Little did we think, as we saw him in God's house on the Sunday previous to the fatal attack, that he was never to tread those courts again; that we were delivering to one immortal being at least, the last public ministrations of grace that would ever fall upon his ear. The manly form, the gentle mien, the thoughtful manner, the apparent vigor, gave hope and promise for future years of toil and usefulness. * * * *—*Episcopal Recorder*, Philadelphia.

Dr. Morton's collection of Crania, the basis of his principal work, is the largest in the world, and is the great feature in the museum of the Academy of Natural Sciences in which it is deposited. It was collected at his own private expense and by his individual exertions. His zeal in scientific research was not less to be admired than his cool judgment, clear discrimination, and deference for the opinion and feelings of others. "In France," said the late lamented Dr. Prichard, "where scientific men have long been devoted, under the patronage of the government, to researches on this subject; in England, possessed of her immense advantages of wealth and intercourse: in the academies of Italy and Germany; in all of these and with all their advantages, nothing has been done which equals the results of Dr. Morton's unaided labors, in a world which we call new."

The impetus which he gave to this branch of science has been felt even in Russia, where the Emperor has founded in St. Petersburg a national museum which can only hope to equal that of our lamented countryman. Wherever science has her votaries, the news of Dr. Morton's death will carry pain. * * *—*New York Tribune of May 20th.*

Dr. Morton was President of the Academy of Natural Sciences of Philadelphia at the time of his decease, and his loss falls with special severity upon the members of the Academy who have found in his life, as their resolutions say, "an example of earnest and successful zeal in the pursuit and promotion of learning, in the cultivation of wisdom and virtue, and in the practice of the highest liberality and benevolence." A marble tablet to his memory, appropriately inscribed, will be placed by the Academy in its hall.

OERSTED.—The name of HANS CHRISTIAN OERSTED, the discoverer of electro-magnetism, has been added to the long list of those whom continental science has recently been called upon to mourn. It has been truly said of him, that the position which he occupied in Denmark was very similar to that of Humboldt in Germany. He was the philosopher, the scientist, the scholar,—the kind friend of youth, the judicious counselor of age,—one whom monarch and citizen alike delighted to honor. Oersted was born 1777, August 14, in Rudkjöbing, a small town on the Danish island of Langeland. The poverty of his parents and the isolation of their little village were alike unfavorable to the attainment of a thorough education. But Oersted, like many of his predecessors in the same path, learned for himself the elements of knowledge, and especially arithmetic, from old schoolbooks which fell in his way, and taught his brother *Anders* who was a year younger, all that he had thus acquired for himself. And like the brothers Humboldt, the brothers Oersted seemed in after life almost to divide between themselves the realm of human knowledge. While in each case one brother followed the paths of actual science and adorned the university and the academy,—the other rose to equal eminence in the other division of human knowledge, and finally became minister of state.

Oersted came to Copenhagen in his 18th year, and devoted himself to his studies with intense zeal. His fellow student, Oehlenschläger, afterwards the celebrated poet, was at this time almost the only person who shared his friendship with his brother, and the intimate friendship thus begun continued undiminished and uninterrupted till dissolved by death.

In 1799, Oersted published his inaugural dissertation on the "Architecture of Natural Metaphysics," (*Architectonik der Naturmetaphysik.*) This treatise shows that, even at that period, his mind was deeply imbued with tastes and sentiments similar to those which characterize the last writings of his life.

At this time he proposed his new theory of the alkalies, a theory which was afterwards universally adopted. In 1800, he was appointed adjunct in the medical faculty of the University, and began to lecture on chemistry and the philosophy of nature.

This was the year in which Volta discovered the battery which bears his name; setting this discovery, as Möller has admirably said, like a milestone at the close of one century and the beginning of the next. All Oersted's energies were immediately enlisted for the new field of research thus opened, and he immediately detected the true law of the decomposition of salts. From this time forward he dedicated himself solely to the career of an investigator, and in the pursuit of his studies visited almost all parts of northern Europe.

His subsequent life is well known to the scientific world. In the year 1820 he discovered the magnetic influence of electricity, thus founding the science of Electro-magnetism and in fact first opening that new course of research into the mutual relations of the several energies of nature, which is still pursued with such brilliant success, yearly leading to more and more astonishing results. Without the discoveries of Oersted, where had been those of Ampère, Arago, Faraday, Seebeck and Melloni? In 1814 he established a Magnetic Observatory at Copenhagen, but has since that time chiefly devoted himself to those sciences which spring from the mutual relation of the material and spir-

itual worlds. His books on "The Spirit in Nature," "Natural Science and Spiritual Culture," "Natural Science in its relation to Poetry and Religion"—must be and continue classic works, whatever may be individual views of the correctness of their philosophy. The bishop of Seeland has very recently published a severe attack upon Oersted's views, occasioned by the publication of his "*Geist in der Natur.*" But although Denmark has been one of the last continental nations to learn how little our knowledge of the truth is advanced or facilitated by contests between theologians and scientists; the reception of Bishop Mynster's book shows that the great fact—that the true interpretation of revelations through moral and through physical media must necessarily coincide—is now at last appreciated in Denmark also.

The fiftieth anniversary (jubilee) of Oersted's appointment to his professorship in the University of Copenhagen was recently celebrated with great pomp. All ranks vied in showing him honor. The king conferred on him the highest civil distinction,—the grand cross of the Dannebrog—the University sent new insignia of his Doctor's degree, with a gold ring bearing a carved head of Minerva, and the citizens presented him with a beautiful countryseat at Friedrichsburg, in the immediate environs of the capital. A late newspaper in narrating the facts, adds, "King and people agree in a strange estimate of the value and station of the scientific man, according to our insular notions. We do not see how they could have improved on this sort of testimonial if he had gained a battle!"

The following account of his burial is from the Athenæum, of April 5:—"It may perhaps be interesting to some of our readers to know how they bury a philosopher in Denmark. The illustrious Oersted has gone to his grave with a *cortège* such as waits on the funeral march of kings. Thirty thousand persons—one-fourth of the entire population of the capital—formed the procession which conducted him to his final place of repose. At the head of this crowd, the King was represented by his first aide-de-camp,—followed by the heir to the crown and other princes of the blood. Then came the Chambers of the Diet, the Ministers, the Council of State, the Clergy, the Professors of the University and of the other educational establishments of Copenhagen, the Academies of Science and Fine Arts and other learned corporations, the army staff, nearly all the members of the diplomatic body, the municipality, the youth of the schools, the trading corporations, and finally men of every rank and class—all contributing their several distinctions to swell the one act of homage to him who had done so much to popularize science in Denmark. The thing was not according to the rules:—the Herald was not fairly represented in a procession like this. But rules which were to be immutable are giving way on every hand:—and the Herald, who shows as so great a figure through the twilight of the middle ages, is a mere phantom in the light of modern days."

B. A. G.

Jacobi.—Carl Gustav Jacob Jacobi was born in Potsdam, 1804, Dec. 10. His father was a silversmith, of the Jewish faith. He was educated under the care of his uncle, F. A. Lehmann, and entered the Gymnasium at Potsdam in 1816, the Berlin University in 1820, dividing his studies between the three departments, Mathematics, Philosophy and Philology. His Dissertation on leaving the University in 1825, is

entitled, "Disquisitiones Analyticæ de Fractionibus Simplicibus," and is a treatise of great analytic value. Among the theses which he defended at this time, was the truth of the couplet of Novalis,

> "Der Begriff der Mathematik ist der Begriff der Wissenschaft überhaupt.
> Alle Wissenschaften müssen daher streben Mathematik zu werden."
>
> The idea of Mathematics is the idea of Science in general;
> All sciences must therefore strive to become Mathematics.

The wide scope of Jacobi's studies and the many-sidedness of his culture, give to his strong opinion a peculiar weight.

He went to Königsberg in 1825, and was appointed Professor in that University in 1827, a post which he retained until his death,—though on account of the severe climate of Königsberg he has resided in Berlin for several years, and lectured in that University in his character of academician. His chief investigations have been connected with the theory of elliptic functions, and are published in the Memoirs of the Berlin Academy and in Crelle's Journal. The first volume of a contemplated collection of his complete works appeared in 1846.

Prof. M. H. Jacobi, the electrician, the discoverer of the galvano-plastic art, now a resident of St. Petersburg, is a brother of the deceased.

An apt illustration of the high repute of Jacobi is furnished by an incident which occurred about a twelvemonth before his death. In consequence of the extreme liberality of the opinions which he entertained at the time, his salary was reduced by the Prussian government. But no sooner had this been done, than the *Austrian* government invited him to the University of Vienna, at a salary equal to the former one, and the Prussians were thus unwillingly compelled not only to restore all arrearages, but also to establish his salary at a higher rate than before.

His personal character was very peculiar. His enthusiasm was great, his prejudices strong, his sarcastic powers hardly exceeded by those of Lichtenberg himself. He took a warm interest in the recent political disturbances of Prussia, although his position was extremely undefined; being characterized at one time by the strongest loyalty, at another by the most fervent republicanism. In Jacobi, science has not only lost one of her brightest ornaments, but a powerful defender of her interests, —a champion who knew not how to yield. In the words of a colleague in a recent letter to the writer, "The loss is not only for science, but for all who honor her, for she has lost a defender, able and earnest, when her welfare was concerned, to set in motion all the powers above and beneath, to break and hew open a path for her." B. A. G.

VI. Bibliography.

1. *Astronomical Observations, made under the direction of* M. F. Maury, Lieut. U. S. Navy, during the year 1846, at the National Observatory, Washington. Vol. II, published by authority of the Secretary of the Navy. pp. lxvi, 442, with an appendix of 167 pp., 4to. Washington, 1851.—This volume commences with an account of several of the prominent instruments of the Observatory, the modes of reducing the observations, and other particulars, which make up the Introduction. The results of the observations occupy the next 427 pages. The appendix contains, 1st, a chapter on Neptune; 2, on the Electro-chronographs; and 3, on Wind and Current Charts. On the

last subject, Lieut. Maury has brought forward much that has not hitherto been published, and views of interest to meteorological science and navigation, whether they are all sustained or not by further study. Some of the views on the Gulf Stream and the northern current we find stated as early as the year 1837 in an article in this Journal by Mr. W. C. Redfield, and in part alluded to in 1835, vol. xxv, p. 131. But great additions have been made to our actual knowledge of oceanic currents and the courses of winds, and greater results promise to reward the skill and energy with which the researches are now prosecuted. We trust that Lieut. Maury may continue to have, and more completely, the coöperation of the Navy Department in carrying out his system of investigations; and we would commend the subject also to the commercial cruisers, who with little effort, might contribute to the general fund, facts of great value to commerce as well as science. Lieut. Maury also presents conclusions with reference to the circulation of the air, from the recent discoveries of Faraday respecting the magnetic character of oxygen, and other deductions from the researches of Ehrenberg on the organic life of the transported dust of the atmosphere. This part of the Report contains extended citations from Ehrenberg's recent work; and in view of the occurrence of South American forms of microscopic organisms in the Atlantic dust off the African coast, he suggests that the dust is carried off by "the whirlwinds which accompany the vernal equinox and sweep over the lifeless plains of the lower Orinoco," while those of "the autumnal equinox, take up the organisms of the upper Orinoco and great Amazon basins." The establishment of such a view will require farther investigation into the organisms of these different regions.

2. *Practical Mineralogy, Assaying and Mining*, with a description of the useful minerals, and instructions for assaying and mining according to the simplest methods; by FREDERICK OVERMAN, Mining Engineer. 230 pp. 16mo. Philadelphia, 1851. Lindsay and Blakiston.—There is much practical information in this little work, but it is not all to be relied on. We learn on the 2nd page that granite is the *oldest* of rocks; that it is *composed of fragments* of other rock or stony matter; it is of great hardness and strength and of *everlasting durability*;—on the 4th page, metamorphic rock, "also called transition rock is the second in age;" "to this class belong a great variety of *minerals* as gneiss, mica slate," &c. "Metamorphic rock often assumes the appearance of granite, *pudding-stone* or stratified rock;" and on page 7 the Connecticut sandstone is ranked with the metamorphic rocks: on page 8 we read under the head of Volcanic Rocks,—"the rocks belonging to this class are often found to be perfectly vitrified and of a glassy appearance *as basalt* and some kinds of lava; the first is found in columns grouped together in isolated mountains or *imbedded in other volcanic rocks*." We might go on in this citation of errors, but this will suffice.—Such a work is calculated to make error, rather than science, popular.

3. *A Chart giving an Ideal Section of the Successive Geological Formations*, with an actual Geological section from the Atlantic to the Pacific ocean, the whole illustrated by the characteristic fossils of each formation; by JAMES HALL.—This geological chart by Mr. Hall is intended for class instruction, and is well adapted for this purpose. It

measures five feet by six, and is conveniently mounted on rollers. The lower two-thirds of the sheet are occupied with an ideal geological section and the upper portion by drawings of fossils. The section is an excellent representation, as far as can be done in a single view, of the general principles of geology. Besides exhibiting the dynamics of the science and the succession of the rocks in due order, with their names in French and German as well as English, the author has given also the more important geographical positions in which the rocks occur. The New York strata as developed by the recent surveys, and the results of the explorations of other parts of our country, are throughout laid down, and a section of the whole country through to the Pacific is added, so that the chart is thus especially adapted for the American student. The drawings of fossils are arranged in groups, those of the same geological system together, and in all amount to two hundred and seventy-five. Mr. Hall's labors in Palæontology, so well known and so honorable to the state which he has served, have prepared him to present this subject with accuracy and completeness; and in no other publication of the kind will the student find presented to the eye so perfect an exhibition of the characteristic organic remains of the several strata. Such a chart has been greatly needed for the geological lecture room, and we know of none comparable with it for extent of information, or fullness, accuracy and neatness of illustration.

4. *The Christian Retrospect and Register*, a summary of the Scientific, Moral and Religious Progress of the first Half of the XIXth century; by Robert Baird, 420 pp., 12mo. New York, 1851.—This work embraces two distinct parts; the first, the progress of the world in general liberty, education, and the sciences; the second, its moral and religious advancement. Dr. Baird, through his intercourse with various nations of Europe and familiar knowledge of their religious history and condition, has been enabled to condense in this work a large amount of valuable information. The learned and excellent author treats separately of the progress of political liberty and education, the enlargement of the bounds of Christendom, the progress of religious liberty and the operations and prospects of the many societies now active for the diffusion of Scriptural knowledge. The portion of the volume devoted to science is by the Rev. B. N. Martin. A complete review was of course impossible in so small a compass. The author, without attempting to give a philosophical exhibition of the development of scientific knowledge, has briefly glanced at many of the steps of progress under the head of the different departments of science and certain of the arts.

5. *Annals of the Lyceum of Natural History of New York.* Vol. V, No. 2, April, 1851.

G. N. Lawrence: On the occurrence of the Caspian Tern (Sylochelidon caspius) in North America, p. 37.

G. N. Lawrence: Description of a new species of Tyrannus—T. Cassinii.—p. 39, and pl. 3, f. 2.

J. P. Giraud: Description of a new species of Helinaia—H. brevipennis.—p. 40, and pl. 3, f. 1.

C. B. Adams: Descriptions of new species of Partula and Achatinella.—p. 41.

C. B. Adams: Descriptions of new shells from Jamaica.—p. 45.

C. B. ADAMS: Analysis of the group of species of Cyclostoma which is represented by C. Jamaicense of Chemnitz.—p. 56; with a note on the genus Stoastoma, p. 64.

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The views taken by this Magazine, of the great financial questions of the day, are not always such as we approve; but then it *discusses* those subjects, and that is a great advantage. It is a fact, which, however unpalatable, we must state, that many men engaged in business are deplorably wanting in almost every element that constitutes an accomplished merchant. If they would lay out a few dollars per year upon such works as the Bankers' Magazine, they would have a rich source of intelligence, the effect of which would soon be felt by themselves. We ought to remark that the work is as well adapted to the wants of business men generally, as to those of the banker. — *Rochester Advertiser.*

THE BANKERS' MAGAZINE AND STATE FINANCIAL REGISTER, for September, is well filled with matter of interest to every reader, but of particular importance to every intelligent banker, broker, or other person extensively engaged in the management of monetary affairs. The editor has evinced great industry and good judgment in the collections and publications in his journal, and he presents matter which is not to be met with, in a connected form, in any other publication. — *St. Louis Republican.*

THE BANKERS' MAGAZINE. — This is the title of a very useful periodical, published at Baltimore, under the editorship of Mr. J. S. HOMANS. It is the only satisfactory record in the country of that important class of statistics referring to *Finance, Currency, and Banking Operations.* The number for November is the most valuable that has yet been issued. The first paper is an article upon the Finances of the War of 1812, of peculiar interest at this time, when the state of the treasury is the subject of such general concern.

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THE BANKERS' MAGAZINE AND STATE FINANCIAL REGISTER. — The August number of this valuable journal is before us, and we regard it as a most excellent number of a very useful publication. We cannot afford space for the enumeration of its contents; the article on the "General Principles of Banking," by J. R. McCulloch, Esq., will, when completed, be an excellent manual upon the subject. "The Public Revenues of Great Britain" gives much very useful and curious information, which has been brought together with a good deal of judgment and industry. The "List of Foreign Bankers," from the *London Bankers' Magazine*, is an instructing article, and will prove very serviceable to travellers. A summary of American law decisions, relative to banks, is a particularly valuable article to all bank officers. No president, cashier, or teller of a bank should be without it. There are many other articles in this number of great merit. We confidently recommend the publication to all who are interested in the subjects upon which it treats. — *National Intelligencer.*

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C. W. JAMES, 1 Harrison street, Cincinnati,—for the Western States,—assisted by J. R. SMITH, J. T. DENT, JASON TAYLOR, J. W. ARMSTRONG, PERRIN LOCKE, W. RAMSAY and G. STEINMAN.

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THE

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[SECOND SERIES.]

ART. XVII.—*Observations on the Pluton Geysers of California;* by FOREST SHEPHERD,* Prof. Economic Geology, in Western Reserve College, Hudson, Ohio.

THERE is a tradition among the Indians of California, that not many years ago, the Chrysopylæ or Golden Gates at the entrance of the Bay of San Francisco were part of the solid land, and that the inland sea receiving the waters of the Sacramento and San Joaquin overflowed the beautiful valleys of San José, Napa and Sonoma, and had its outlet in the vicinity of Monterey.

Other more recent California explorers affirm that in the present bay of San Francisco they have discovered standing trees completely petrified, to which they have made fast their boats at low tide. The numerous dislocations observed in the tertiary strata, together with the great number of specimens of petrified wood and deposits of lignite found upon the shores of the bay, also signs of thermal action at the southeastern section of the bay, induced me to give so much credence to the above and other traditions, as to enter upon some careful examinations with reference to them. In the course of my investigations, I have explored some remarkable geysers in the Pluton valley; and these form the main subject of my present communication.

On my way to the Pluton valley, I first coasted around the Bay of San Francisco in an open boat, examining the rocks in its vicinity. At the entrance of Napa valley and about two

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* From a letter addressed to Thomas Denny, Esq., New York city, and communicated by him to this Journal.

miles from the present tide, I discovered a belt of remarkably hard and heavy limestone, evidently fossiliferous and yet changed in some places by metamorphic action. In breaking into this bed of limestone, however, I was surprised to find imbedded in the solid rock, sharks teeth as perfect in their serrated edges as those of present living species swimming in the bay only two miles distant. I examined the range of hills eastward about one mile, which bounds and divides Napa valley from Suisun, and there I found the rocks to be a porphyry, with numerous springs flowing out at the base. I applied my thermometer and was surprised to find no two springs of the same temperature, they ranging from seventy-eight degrees Fahrenheit downward. I now travelled about thirty miles northward in Napa valley, following the above mentioned chain of hills to the thermal springs of Messrs. Ritchie and Tucker, where I found the temperature of different springs as follows:—

No. 1,	105	degrees, Fah.	No. 11,	132	degrees, Fah.
2,	120	"	12,	169	"
3,	144	"	13,	129	"
4,	133	"	14,	150	"
5,	147	"	15,	131	"
6,	144	"	16,	128	"
7,	129	"	17,	93	"
8,	124	"	18,	100	"
9,	120	"	19,	120	"
10,	131	"	20,	118	"

These springs are all embraced in a half mile square of level bottom land near the base of a small hill or mound of conglomerate rock about one hundred and fifty feet in height. The same kind of rock also extends underneath the springs. There is little or no opportunity for surface cold water to commingle with them, and it is a remarkable fact that they are continually changing their temperature, so that one that is now moderately warm will in the space of a few weeks or months become hot beyond endurance. This shifting of the internal heat greatly excited my curiosity, and on enquiring, I learned from Mr. Cyrus that the Indians had pointed out a place near the foot of Mount St. Helena where the hot waters formerly flowed, but had now ceased. I believed this to be a good opportunity to test the truth of their tradition, and repaired to the spot. Externally there was no uncommon appearance to designate the locality. Neither a surplus nor scarcity of vegetation, and no appearance of scoria, tufa or travertine, as might have been expected. I found one place, however, slightly warm on the surface, which on excavating to the depth of two feet became so hot that I could not bear my hand in the mud and clay. I inserted the bulb of my thermome-

ter, and the mercury at once rose to one hundred and twenty degrees. From observations already made by myself and in company with Professor James Nooney, I now felt that I could trace the line of thermal action, and my next object was to find the seat or focus of its greatest *intensity*. To accomplish this I was so fortunate as to have the aid of Messrs. P. Cyrus, J. Cyrus, and B. F. Briggs, three excellent young gentlemen and experienced hunters. We travelled northwesterly from the head of Napa valley, and after encamping one or two nights in the rain, and wandering through almost impenetrable thickets, reached the summit of a high peak on the morning of the fourth day. On the west we saw the vast Pacific. On the south, the Bay of San Francisco, Mount Diabalo,* Sonoma and Napa valleys. On the southwest, the valleys of Santa Rosa and Russian river. On the east, the lofty range of the Sierra Nevada: while on the north, almost immediately at our feet, there opened an immense chasm apparently formed by the rending of the mountains in a direction from west to east. The sun's rays had already penetrated into the narrow valley and so lighted up the deep defile, that from a distance of four or five miles, we distinctly saw clouds and dense columns of steam rapidly rising from the banks of the little river Pluton. It was now the eighth of February: the mountain peaks in the distance were covered with snow, while the valley at our feet wore the verdant garb of summer. It was with difficulty we could persuade ourselves that we were not looking down upon some manufacturing city, such as Pittsburg or Wheeling, until by a tortuous descent we arrived at the spot where at once the secrets of the inner world opened upon our astonished senses. In the space of half a mile square we discovered from one to two hundred openings through which the steam issued with violence, sending up columns of dense steam to the height of one hundred and fifty to two hundred feet, like our largest ocean steamers, and gradually diminishing to engines of one or two horse power. The roar of the larger tubes could be heard for a mile or more. The sharp hissing of the smaller ones is still ringing in my ears. Many of them would work spasmodically, precisely like high pressure engines. Throwing out occasional jets or volumes of hot scalding water some twenty or thirty feet, endangering the lives of those who rashly venture too near. In some places the steam and water come in contact so as to produce a constant "*jet d'eau*" or spouting fountain with a dense cloud above the spray, affording vivid prismatic hues in the sunshine.

Numerous cones are formed by the accumulation of various mineral salts and a deposit of sulphur crystals with earthy matter,

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* Mount Diabolo is reported to be an extinct volcanic cone.

which often harden into crusts of greater or less strength and thickness. Frequently the streams of boiling water would mount up to the top of the cones with violent ebullition. Some of the cones appear to be immense boiling cauldrons, and you hear the lashing and foaming gyrations beneath your feet as you approach them. It is then a moment of intense interest. Curiosity impels you forward—fear holds you back; and while you hesitate, the thin crust under your feet gives way, and you find yourself sinking into the fiery maelstrom below. The writer on one occasion heard the rushing of water under his feet. He struck down an axe which on the first blow went through into the deep whirlpool the whole length of the helve. He withdrew it and cut an opening, which revealed a stream of angry water, boiling intensely and of unknown breadth and depth. He continued to enlarge the opening until the stream was seen to be five or six feet in breadth, leading on indefinitely into the dark caverns beneath the mountain. This geyser is called *Agassiz's Maelstrom.*

Another place where a large volume of water boils up violently and settles in a circular basin and has also a steam tube by its side, is called *Silliman's Fountain.* Another, is named the *Panther Geyser*, from the circumstance that a huge wild panther had taken up his residence on the bank of the warm mound and seemed quite unwilling to leave his comfortable habitation. Another, where the waters gyrate with a loud noise "*in gurgite vasto*" is called *Pluto's Cauldron.* Another, the *Ocean Steamer, &c.*

At the base of the cones, in the bottom of the ravines, and in the bed and on the north bank of the river Pluton, springs almost innumerable break out, which are of various qualities and temperatures, from icy coldness up to the boiling point. You may here find sulphur water precisely similar to the celebrated *White Sulphur* of Green Brier County, Va., except its icy coldness. Also red, blue and even black sulphur water, both cold and hot. Also pure limpid hot water without any sulphur or chlorine salts, calcareous hot waters, magnesian, chalybeate, &c., in almost endless variety. Every natural facility is afforded for either vapor, shower or plunging baths. Where the heated sulphuretted hydrogen gas is evolved, water appears to be suddenly formed, beautiful crystals of sulphur deposited (not sublimed as by fire), and more or less sulphuric acid generated. In some places the acid was found so strong as to turn black kid gloves almost immediately to a deep red. Where the heated gas escapes in the river Pluton, such is the amount of sulphur deposited that the whole bed of the stream is made white for one or two miles below, similar to the White Sulphur Spring in Virginia. From numerous experiments made here and in the mountains of Virginia, I am confident that all sulphur springs possess a high temperature after descending below the cold surface water. Notwithstanding that

the rocks and earth in many places are so hot as to burn your feet through the soles of your boots, there is yet no appearance of a volcano in this extraordinary spot. Were the action to cease, it would be difficult after a few years to persuade men that it ever existed. There is no appearance of lava. You find yourself standing not in a solfatara nor one of the salses described by the illustrious Humboldt. The rocks around you are rapidly dissolving under the powerful metamorphic action going on. Porphyry and jasper are transformed into a kind of potters clay. Pseudo-trappean and magnesian rocks are consumed much like wood in a slow fire, and go to form sulphate of magnesia and other products. Granite is rendered so soft that you may crush it between your fingers, and cut it as easily as bread unbaked. The feldspar appears to be converted partly into alum. In the meantime, the boulders and angular fragments brought down the ravines and river by the floods, are being cemented into a firm conglomerate so that it is difficult to dislodge even a small pebble, the pebble itself sometimes breaking before the cementation yields.

The thermal action on wood in this place is also highly interesting. In one mound I discovered the stump of a large tree silicified; in another a log changed to lignite or brown coal. Other fragments appeared midway between petrifaction and carbonization. In this connection, finding some drops of a very dense fluid and also highly refractive, I was led to believe that pure carbon might under such circumstances crystallize and form the diamond. Unfortunately for me however, I lost the precious drop in attempting to secure it.

A green tree cut down and obliquely inserted in one of the conical mounds, was so changed in thirty-six hours that its species would not have been recognized except from the portion projecting outside, around which beautiful crystals of sulphur had already formed.

From the thermal exhalations and the amount of sulphur deposited, it might be supposed that the progress of vegetation would be retarded. But such is not the fact. On the contrary it is greatly facilitated. The *Quercus sempervirens* or evergreen oak, flourishes in beauty within fifty feet of the boiling and angry geysers. Maples and alders from one to two feet in diameter, grow within twenty or thirty feet of the hottest steam pipes. This, however, may be accounted for by the cold surface water flowing down from the adjacent mountain. Here too the birds build their nests and "sing among the branches." Multitudes of grizzly bears make their beds on the warm grounds. Panthers, deer, hares, and squirrels, also take up their winter quarters in the very midst of the geyser mounds. Farther down the stream on the terraced banks of the limpid Pluton, vegetation (as one gentlemen has aptly expressed it) "*actually runs wild*," and the winter months exhibit all the fancied freshness of primeval Eden.

I have now traced the influence of this thermal action from two to three hundred miles on the Pacific coast in California, but only in this place have I been permitted to witness its astonishing intensity. The metamorphic action going on is at this moment effecting important changes in the structure and conformation of the rocky strata. It is not stationary, but apparently moving slowly eastward in the Pluton valley.

I would respectfully invite the attention of geologists to this cause of action, which hitherto has been too little studied and at present is not perfectly understood. The investigation will probably aid in accounting for the existence of many springs independent of ordinary Artesian flow, the formation of deep and varied soils, of beds of sulphur, rock salt, chalk, clay, hydrous iron ore, gypsum, &c., and perhaps extensive sections of breccia and conglomerate like those which traverse our continent.

California, March 17th, 1851.

ART. XVIII.—*Report of* Prof. ALEXANDER D. BACHE, *Superintendent of the United States Coast Survey, showing the progress of that work for the year ending October*, 1850. Ex. Doc., No. 12, 31st Cong., 2nd Session.

WE propose to devote a short notice, such as our space will allow, to the recent Report of Prof. A. D. Bache, Superintendent of the United States Coast Survey, showing the progress and state of that work, up to the latter part of 1850.

Our readers may be presumed to be somewhat acquainted with the nature of a work which has such an important bearing on the great interests of our country, and the advancement of science. We need, therefore, but briefly refer to the general plan and scope of the Survey.

The grand object—an accurate delineation of our coast and its adjacent waters—is pursued by a system; 1st, of primary triangulation, founded on the nice admeasurement of a base line, and embracing, wherever practicable, points of prominent interest—accompanied by astronomical and magnetic observations, for the determination of the latitude and longitude of such points, and the variation of the compass; 2nd, of more minute triangulation, and accurate topography of the shores; and 3d, of hydrographic observations, extending to all that may help the mariner to a knowledge of the dangers or facilities of our coast navigation, in the present, and all that may point out to the government judicious modes of indicating those dangers, or increasing those facilities, in the future.

The prosecution of this primary plan allows, and is used for, the incidental promotion, not only of the discovery of phenomena and laws which may afford new helps to the general science

of navigation, but also of a worthy contribution, from our country, to the great magazines of observations which the governments and *savans* of the civilized world are combining to store as the treasure house of future science.

The most distinguished foreign associations and journals have expressed their attentive admiration of the work, and the hopes which they indulge of its manifold results. We cannot forbear to instance the "Bulletin de la Société de Géographie," (Paris, Jan., 1851,) which, after an extended notice, adds; "In our mention of the eminent services rendered by the Coast Survey to science and to humanity, we have indicated but a small part of the results of this admirable enterprise. Directed in all its branches with zeal and activity, it cannot fail to add each year to the consideration with which it is regarded, not only in the United States, but in every country where science and its applications to the arts of life are justly appreciated." Of the present head of the work, it says: "The new superintendent was called with unanimity to this eminent post: signalized to the esteem of his fellow-citizens by useful publications, appreciated by the principal academies of Europe, he has acquired a universal renown by services daily rendered to science, and by ameliorations of every description introduced in the various branches of the Coast Survey."

Under the system established by the present superintendent, our coast has been divided into sections (nine for the Atlantic and two on the Pacific), in all of which the work is prosecuted simultaneously and separately. The different parts of the work will thus serve, in future, to verify each other, where the triangles meet. By this plan, moreover, the resulting benefits of the survey, instead of being postponed, or partially bestowed, are distributed throughout the country, during even the first stages of the work, in the different sections—a consideration, in its favor, of high practical moment, there being many cases, on various parts of our coast, in which even an approximation to accuracy of information is of immediate importance, to remedy the omissions or mistakes of existing charts.

The delineation of the Atlantic coast, as far south as that of North Carolina, has, in its essentials, advanced well nigh to completion; and a large number of extended and useful charts have been published. In our southern and western sections, the preliminary work is being rapidly pushed, together with, here and there, surveys in detail of important points, examined with a view to present necessities, or in compliance with special requests from the communities interested. Much valuable information, on those coasts, has indeed been already acquired and made public.

Within the past year, the harbor of Beaufort, N. C., has been surveyed, and a sketch published, as also of Oregon and Hatteras inlets, which sketches have been gratuitously distributed.

On the coasts of South Carolina and Georgia, the survey has been in progress since 1847. A base line has been measured on Edisto island, and the primary triangulation commenced. A preliminary base has been measured near Savannah, and the triangulation of that river commenced. The triangulation of N. Edisto inlet (harbor of refuge) is far advanced. The hydrography of Charleston harbor and bar is nearly completed, and hydrographic reconnaissances have been made off the sounds of St. Helena and St. Andrew.

In the Florida section, a reconnaissance of the Florida reef, keys, and adjacent main, has been completed from Cape Florida to the Tortugas. The topography and hydrography of Key West, and the adjacent islands and main, have been executed, a reconnaissance made of Cape Canaveral shoals, and one of Cedar Keys commenced. The work indicates a new channel for entering the harbor of Key West. This section was entered on in 1849.

On the coast of Alabama and Mississippi, the primary and secondary triangulations, entered on in 1846, are advancing. The hydrography and topography of Mobile bay and the delta near the city are completed.

In the section extending along the coasts of Louisiana and Texas, entered upon in 1848, the primary and secondary triangulations are in progress. The hydrography and topography of the approaches and vicinity of Galveston are nearly completed.

The parties sent to the coasts of Oregon and California have been hampered for want of means to carry on the work. The results, so far, have been—a general reconnaissance of the coast of California, from Monterey to the mouth of Columbia River, with charts and sailing directions—preliminary surveys of that river and of the bays of San Francisco and San Pablo—special observations and reports on Cape Conception, (which has been called the Hatteras of the western coast,) Cape Disappointment and some other prominent points.

From this general view, we may proceed to remark such striking features or new observations, especially with reference to their general scientific interest, as offer themselves in the report of Prof. Bache, under the respective heads of, 1st, the geodetic, and 2d, the hydrographic, portions of the work.

I. The correct measurement of a base line is the problem on whose practical solution must rest the accuracy of the Survey, in all its subsequent stages. Upon this head, the French scientific journal, before quoted, justly remarks that "many modes of procedure have been employed. The best, beyond all doubt, is that of Professor Bache, who by a skillfully arranged apparatus, has arrived at the most exact precision, and has succeeded in correcting several defective determinations of his predecessors."

The measurement is now pursued with an apparatus devised by Professor Bache, founded on the known system of compensating bars, but perfected by new precautions and nice contrivances of mechanical adjustment. Heretofore, no further approximation to accuracy of compensation had been attained, than resulted from joining together bars, of about the same size and surface, of different metals. The masses of the bars have been proportioned by Prof. Bache upon the principle that the absorption varies directly with the conducting power and inversely with the specific heat, of the material. Hence masses proportioned to the ratios of those constants, and having equal surfaces, from which conditions their linear dimensions may be deduced, would theoretically bear to each other the due compensating relation. Two sources of error however remain—the inexactness of the values assumed for those constants, and the different rapidity of absorption of the surfaces, during changes of temperature. These are obviated by proportioning the bars by actual experiment, subsequent to the calculated approximation, and by coating the materials respectively with varnishes suitable to each; so that the absorption of both will be equal in a given time and the compensating relation continue during changing temperatures. The bars while in use are constantly compared with the standard bar. They have been exposed beforehand to a higher temperature than they can be while in use, in order to give them a set, and are always protected by a covering, throughout the greater part of their length. These precautions, with arrangements for perfect contact, of which our limits forbid description, have ensured all the accuracy desirable. During the season embraced in this report, a base line of $6\frac{2}{3}$ miles was measured, in the whole of which the probable accidental error did not exceed one-tenth of an inch.

The Chesapeake triangulation will furnish the length of an arc of the meridian of over $2\frac{1}{2}$ degrees, measured, with but moderate deviation, on each side of the central meridian.

The local attraction at the astronomical stations having been found to modify essentially the determinations, those stations have been multiplied, and with the astronomical have been united magnetic and meteorological observations. The method of azimuth by observations at equal intervals before and after the culmination of a circumpolar star has given excellent results, requiring but brief computations.

By telegraphic connection with the coast stations, the observations of moon culminations and occultations at Cincinnati have been made available for differences of longitude from Europe. In general, it is to be remarked that the observations of scientific men, where they could be made available, have been procured for the Survey, and various distinguished professors have been employed to compute results from the materials accruing to the

work. In this wise, the appropriation for the Survey is made, while effecting its own end, to contribute to the maintenance and encouragement of a class devoted to science—and who may perhaps thus be assisted to repay their country in future fame, as well as in present labor.

In addition to the employment alluded to of telegraphic connections for determination of differences of longitude, researches have been prosecuted on the velocity of the galvanic current. A measurable interval having appeared in the recording of signals at different points, experiments were instituted, connecting the Washington station with Cambridge, Mass., St. Louis, and Charleston, S. C., under various circumstances. The results indicate a velocity of about 15,400 miles per second, by the iron wires, while it appears probable that, in passing *through the ground*, the wave has not a velocity exceeding two-thirds of the former. In the course of these experiments, interesting phenomena have been noticed, indicating apparent crossing and interference of the galvanic waves departing from the two poles of the telegraphic circuit.

Under an arrangement for ascertaining differences of longitude from Europe, by the transportation of chronometers, one series of results has been completed, and another is commencing. Mr. Bond, Director of the Cambridge Observatory, who had the immediate charge of the matter, states the very curious fact that the eastern passages give a greater difference of longitude than the western—and this too uniformly to be the result of accidental errors of the chronometers.

In the conduct of the Survey, it has been difficult to ascertain the best season for its various operations on different parts of the coast, the most pleasant weather not being always the most suitable, especially when the lines of sight are long. In the Florida section experience indicates the months from November to June (embracing parts of each, and including the intermediate months except March) as best for triangulation; and the same months, substituting March for June, as best for topography.

At the office of the Survey, the reproduction of engraved plates by the electrotype process has been pursued with complete success. The method consists in washing the plate with an alcoholic solution of iodine, and exposing to the action of a strong light, before placing it on the battery. In replacing a destroyed plate, the practicability has been proved of cutting up plates in the engraving, distributing the parts to several engravers, and reproducing the whole in one plate. The mode adopted was to secure the parts by screws to a copper plate and fill in with copper filings the intermediate spaces, made exceedingly small by close filing of the edges of contact. The metal formed was equally good throughout; and there remained only a few days' labor of an engraver to unite the parts.

II. The hydrographic surveys have yielded important discoveries of new and better channels, and of dangers heretofore unknown. Of the former class are Gedney's channel at the entrance of New York, Blake's in Delaware Bay, an entrance of twenty-one feet water on Mobile bar, and a new harbor on the dangerous coast of North Carolina. Of the latter, are the discoveries of Davis' and other shoals near Nantucket, in the most frequented path of commerce, several on the southern coast, and the new delineation of shoals off the coast of Maryland and off Cape Hatteras, differing almost entirely from the data previously furnished by the best authorities. Professor Bache remarks that such results, though more striking, are not more useful, than the accurate delineation of the harbors, bays, and sea-coast, which the ordinary operations are continually furnishing to navigators. He adds, that some of the differences observed between the recent surveys and those on which former charts were founded, are no doubt the results of actual changes; but there are no facts which prove that any important channel has been obliterated without being replaced by another, or has diminished in depth. The portions of our coast which really do change will be made known in the course of the survey, and the permanent marks furnished by the land work will permit re-examinations to be made, whenever required, at small expense and by ordinary means. The examinations relative to the entrance of Columbia river, heretofore so much dreaded by mariners, show that there have been great changes, but always a good channel, and its recent navigation has been without accident.

At various points, observations of tides and currents have been kept up minutely. Those of the tides at Cat Island are under discussion, as of a remarkable class, giving in general but one high and one low water tide during twenty-four lunar hours. These tides are supposed to depend upon the interference of the diurnal inequality (12-hour tide) wave with the semi-diurnal (6-hour tide) wave,—at least their variations may be traced and predicted from such a hypothesis.

The changes of a shore line by the action of storms and winds, and the encroachments of the sea upon the land, have been discussed by observers at Long Island and at Sandy Hook, respectively. The former of these infers, from tradition and examination, that deeper water is, in general, to be expected in the same places at present than formerly; but about the same depth at the same distance from the beach, as the sea probably carves out the same form of bed in all its course of encroachment. At Sandy Hook, where there has been a marked motion of its northern extremity to westward, the observer finds that, whenever there are natural obstructions to the wind, sand hills are formed and the beach preserved. He infers the feasibility of preserving and controlling the formation of the beach, by hedges

set with reference to the prevailing winds. At the same time, he regards the wind as having but small influence, as a first cause, in effecting these changes. The sand seems to be first thrown up by heavy seas and during storms, afterwards, when dry, to be carried about by the wind and deposited, until so near the level of high water as to be prevented by its dampness from rising with the winds.

In the western part of Mississippi sound, the water has changed from salt to fresh, owing to a crevasse through which the water of the Mississippi river enters Lake Ponchartrain, and thence reaches the Sound. The shell fish have been destroyed, and, if the crevasse continue, the character of that region may change materially.

The character, as well as the configuration of the bottom of the ocean is ascertained, and laid down on the charts of the Survey. Specimens of the bottom, obtained by soundings off the coast, are regularly collected and preserved. Their variety will often afford the mariner the means of relying on his lead for his position. The materials brought up in the deep sea soundings have, under the microscope, proved of the highest scientific interest. They have been already discussed by Professors Bailey and Agassiz.

Experiments have been made to ascertain the amount of uncertainty in ocean soundings, under different circumstances. The results obtained are of practical importance, as deciding the degree of accuracy necessary to be arrived at in observing the tides for the correction of soundings.

The observations of local attraction on board the iron steamer Jefferson have given the curious result of a difference not amounting to as much as four degrees, when heading towards opposite points of the compass. It is not known that any such case has ever before been observed.

In no point of view perhaps, can the results of the survey be made available for purposes of greater immediate importance, by the government to whom they are submitted, than in the establishment of light-houses, and the like facilities, for the guidance of our navigation. A wise selection is far more advantageous than an undue multiplication of such works. Accordingly, the attention of the parties employed in the various sections of the Coast Survey is constantly and minutely directed to the examination and selection of suitable points for light-houses, beacons, and buoys, and the determination of the best modes of construction for attaining the objects in view at the different localities. We trust that the attention of our government will not slumber over this subject, but that a judicious use of the knowledge thus acquired will cause to be devised and carried out, a system which shall lend new wings to our commerce, alleviate the hardships and lessen the dangers of the mariner, and lighten the hearts of those at home, whose fancy tracks in dreams his dangerous path.

Art. XIX.—*On Coral Reefs and Islands;* by James D. Dana.—Part Third.

From the Report on Geology of the Exploring Expedition under Capt. Wilkes, U.S.N.

Structure, Growth, and Habits of Coral Zoophytes.

1. *Structure and Growth of Zoophytes.*

A singular degree of obscurity has been thrown around the growth of coral zoophytes and coral formations, through the various speculations which have been offered in place of facts; and to the present day, the subject is seldom mentioned without the qualifying adjective *mysterious* expressed or understood. Some writers, scouting the idea that reefs of rocks can be due in any way to "animalcules," talk of electrical forces, the first and last appeal of ignorance. Others call in the fishes of the seas, suggesting that they are the masons, and work with their teeth in the accumulation of the calcareous material. Very many of those who discourse quite learnedly on zoophytes and reefs, imagine that the polyps are mechanical workers, heaping up these piles of rock by their united labors; and science still retains such terms as polypary, polypidom, as if each coral were the constructed hive or house of a swarm of polyps, like the honeycomb of the bee, or the hillock of a colony of ants.

It is vain to hope to understand fully the works of Him who is himself infinite and incomprehensible. The scrutinizing eye of science penetrates with far-reaching sight the system of things about us, and in the dim limits of vision reads everywhere the word mystery. All life, animal and vegetable, and all that is inanimate, declare it; surely there is no special reason, except such as may arise from want of study and consideration, for attributing it pre-eminently to the humblest grades of existence.

It is not more surprising nor a matter of more difficult comprehension that the polyp should form coral, than that the quadruped should form its bones, or the mollusc its shell. The processes are similar, and so the result: in each case it is a simple animal secretion, a formation of stony matter from the aliment which the animal receives, produced by certain parts of the animal fitted for this secreting process. This power of secretion is the first and most common of those that belong to living tissues; and though differing in different organs according to their end or function, it is all one process, both in nature or cause, whether in the animalcule or in man. Coral is never, therefore, an agglutination of grains made by the handywork of the many-armed polyps: for it is no more an act of labor than bone-making in ourselves. And again, it is not a collection of cells into

which the coral animals may withdraw for concealment, any more than the skeleton of a dog is its house or cell: for every part of the coral of a polyp in most reef-making species is enclosed *within* the polyp, where it was formed by the secreting process.*

It is important that this point should be thoroughly understood, and fully appreciated. That error may no longer be perpetuated, the words polypary and the like, have been rejected by the author in his volume on Zoophytes, and the more familiar term *corallum* has been used instead.† With this introductory explanation, we proceed.

a. Structure of Coral Animals or Polyps.—A good idea of a coral polyp may be had from comparison with the garden aster: for the likeness in external form and delicacy of coloring is singularly close. The aster consists of a tinted disk bordered with one or more series of petals; and in exact analogy, the polyp-flower, in its most common form, has a disk often richly colored, fringed around with petal-like organs called tentacles. Below the disk, in contrast with the slender pedicel of the plant, there is a stout cylindrical pedicel or body, often as broad as the disk itself, and usually not much longer, which contains the *stomach* and internal cavity of the polyp: and the *mouth*, which opens into the stomach, is placed at the centre of the disk. Here, then, the flower-animal and the garden-flower diverge in character, the difference being required by the different modes of nutrition in the two kingdoms of nature.

There are many species of polyps, which have all the external and internal characters of coral polyps, yet secrete no lime or coral. Our descriptions of structure may be best drawn from them, and afterwards the single peculiarity of the coral-making polyp—its secretion of coral—will come under consideration. The species here referred to are called *Actiniæ* in science, in allusion to the radiated or aster-like flower which forms the summit of the animal.‡ There is the same allusion in the common appellation *Sea-anemone.* The richest anemones, daisies and tulips of our gardens would not rival them in beauty, neither will

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* It is not, perhaps, within the range of science to criticise the poet; yet we may say in this place, in view of the frequent use of the lines even by scientific men, that more error in the same compass could scarcely be found than in the part of Montgomery's Pelican Island, relating to coral formations. The poetry is beautiful, the facts nearly all errors—if literature allows of such an incongruity. For ourselves, we think the poet transcends his appropriate limits when false to nature.

† See page 15, of the Report on Zoophytes. The term Corallium has been set aside by authors because of its being used for a genus of corals. *Corallum* is an old form of the same word, as particularly explained on the page just referred to, and is not liable to this objection. The true nature of calcareous corals was first pointed out by Milne Edwards and Ehrenberg.

‡ From ακτις, *a ray of the sun.*

they exceed them in the size of their flowers; for a breadth of two and three inches is common. The polyps here alluded to, along with the coral polyps allied, constitute the order or division of zoophytes called ACTINOIDEA.*

The Actiniæ are entirely fleshy, and usually live attached by their lower extremity to the submerged rocks of the shores. The mouth, at the centre of the flower-like disk forming the summit of the animal, is a simple opening without teeth or appendages of any kind. The tentacles—the petals of the flower—are tubular organs, and communicate internally with the interior cavity of the animal. The animal contracts, when disturbed, and conceals the flower by rolling inward over it the margin bearing the tentacles; and in this state it seems like a lifeless lump of animal matter. Left quiet for a while, it again expands and appears as before. This expansion is produced by receiving water into the interior from without, mostly through the mouth, and thus filling the tentacles and swelling out its fleshy body. They are generally found expanded with the mouth wide open to receive their prey. As they are fixed to the rocks, they must wait for their food to come to them. When a crab, shell-fish, or anything alive, within the capabilities of their bodies, comes within reach, they usually secure it by closing upon the victim the tentacles, (which commonly have a stinging power,) and pushing it into the mouth. In many species the tentacles are too short to aid in capturing food except it be by stinging. These organs subserve also the purpose of aerating the blood, a function in which all parts of the body are more or less concerned.

The interior of the actinia contains a cylindrical stomach suspended from the disk, which opens at bottom into the general cavity of the body. This general cavity, below the stomach and around it, is divided into compartments by radiating fleshy lamellæ, the larger of which in their upper part connect the stomach with the sides of the animal. The most important function of these lamellæ is that of reproduction, some being spermatic, and the others bearing clusters of ova. These ova leave the body by passing out through the stomach and mouth; but in many instances this does not take place till the young animal has proceeded from them. The refuse from the food after digestion in the stomach is also ejected by the mouth, as this is the only opening to the alimentary cavity. Other excrementitious matters, separated on the final elaboration of the chyle and its assimilation, may escape through the sides of the animal, the openings at the extremities of the tentacles, or in general by whatever pores or passages water may be ejected in the contraction of the animal.

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* This term alludes to their general resemblance to Actiniæ.

One of the most singular peculiarities of polyps is their ready restoration of a lost part. Even a fragment will go on to complete the entire animal again: as with the fabled hydra of old, the knife is used but to multiply, for every section becomes a new animal.

In all the points mentioned in the description here given, the polyp of ordinary coral and the actinia are identical.

b. Process of Budding.—There is one mode of reproduction which, although having no necessary connection with coral secretions, belongs almost exclusively to coral polyps. This is *reproduction by buds;* and the process is so similar to the production of buds in vegetation, that a remembrance of the latter will aid much in conceiving of it. The bud generally commences as a slight prominence on the side of the parent: the prominence enlarges, and soon a circle of tentacles grows out, with a mouth at the centre; enlargement goes on till the young finally equals the parent in size. Thus by budding, a compound group is commenced; and it is evident that if the parent and the new polyp go on budding again, and so on, the compound group may continue to enlarge. This is the fact in nature. The polyps, one and all, continue propagating by buds, until in some instances thousands, or hundreds of thousands, have proceeded from a single one, and the colony has spread to a large size. Such is the Madrepora and Astræa. There are modifications of this process, analogous to those in vegetation, but we need not dwell upon them in this place.

It is obvious that the connection of the polyps in such a compound group must be of the most intimate kind. The several polyps have separate mouths and tentacles, and separate stomachs; but beyond this there is no individual property. They coalesce, or are one, by intervening tissues, and there is a free circulation of fluids through the many pores or lacunes. The zoophyte is like a living sheet of animal matter, fed and nourished by numerous mouths and as many stomachs. In some species the coalescence is confined to the lower half of the polyps, or to a still less part; and in this case the animals project above the general living surface. Polyps thus clustered, spreading at summit a star of tentacles, constitute the flowering zoophytes of coral reefs.

Those coral animals which do not bud are to all external appearance true actiniæ. The existence of coral in the living coral zoophyte is nowhere apparent, and would not be suspected if not previously known; for, as before stated, it is wholly internal, and the visible exterior is the fleshy skin of the polyp.

c. Secretion of Coral.—We have already remarked on the general nature of coral secretions. These secretions, it should be farther observed, increase within simultaneously with growth,

and every new animal adds to those previously formed. They go on throughout the sides and base of each polyp, excepting generally the exterior skin, as above stated; and the whole forms a calcareous framework penetrated by the animal tissues, some of these tissues corresponding to and occupying the cellules of the corallum, and others penetrating the solid parts in minute ramifications. Coral is also secreted between the radiating fleshy lamellæ of the internal cavity of the polyp, producing the radiated calcareous lamellæ which constitute the star of a cell. In the corallum of a Madrepora or an Astræa each surface cell or star belonged to a separate polyp, and the star was formed as here explained.

It would lead to too long a digression from the main topic before us to explain the principles upon which the forms of zoophytes depend. They are dwelt upon at length in another volume. In this place we may briefly allude to the principal varieties of form proceeding from the budding process, and to a single point in their mode of growth, upon which much of their importance in reef-making depends.

d. Forms of Actinoid Zoophytes.—Zoophytes imitate nearly every variety of vegetation. Trees of coral are well known; and although not emulating in size the oaks of our forests,—for they do not exceed six or eight feet in height,—they are gracefully branched, and the whole surface blooms with coral polyps in place of leaves and flowers. Shrubbery, tufts of rushes, beds of pinks, and feathery mosses, are most exactly imitated. Many species spread out in broad leaves or folia, and resemble some large-leaved plant just unfolding: when alive, the surface of each leaf is covered with polyp flowers. The cactus, the lichen clinging to the rock, and the fungus in all its varieties, have their numerous representatives. Besides these forms imitating vegetation, there are gracefully modelled vases, some of which are three or four feet in diameter, made up of a network of branches and branchlets and sprigs of flowers. There are also solid coral hemispheres like domes among the vases and shrubbery, occasionally ten, or even twenty feet in diameter, whose symmetrical surface is gorgeously decked with polyp-stars of purple and emerald green.*

All the many shapes proceed in each instance from a single germ, which grows and buds under a few simple laws of development, and thus gives origin either to the branch, the broad leaf, the column, or the hemisphere.

e. Life and Death in Concurrent Progress.—But the more massy forms would not exist, and others would be of diminutive

* See Report on Zoophytes, pp. 29 and 59–61.

size, were it not for a peculiar mode of growth which characterizes most coral zoophytes.

Life and death are here in concurrent or parallel progress, a condition favored by the existence of coral secretions. In some instances, a simple polyp, while growing at top and constantly lengthening itself upward, is dying at its lower extremity, leaving the base of the coral bare, and destitute of any living tissues. The polyp thus continues rising in height, and death progresses below at the same rate, till at last the live polyp may be at the extremity of a coral stem many times its own length. This process is illustrated by figures on pages 62 and 78 of the Report on Zoophytes.

In species which bud and form large groups, the same operation takes place. In some instances the summit polyp or polyps bud and grow, while at a certain distance below the summit, the work of death is going on and polyps are gradually disappearing. There is thus a certain interval of life, the length of which interval is different for different species. There are zoophytes which grow to a height of several feet, and still only the upper one or two inches are living. The recent polyps at the top of the column are active with life and vigorous in reproduction, while the more aged below, having reached the fixed limits of their existence, are disappearing. The enduring coral remains, and constitutes the basement or stage of action for future generations of polyps.

But this death is not in progress alone at the base of the column or branch. Generally the *whole interior* of a corallum is dead, a result of the same process with that just explained. Thus, a Madrepora, although the branch may be an inch in diameter, is alive only to a depth of a line or two, the growing polyps of the surface having progressively died at their lower or inner extremity as they increased outward.

The large domes of Astræas, which have been stated to attain sometimes a diameter of ten or twenty feet, and are alive over the whole surface, owing to a symmetrical and unlimited mode of budding, are nothing but lifeless coral throughout the interior. Could the living portion be separated, it would form a hemispherical shell of polyps, in most species about half an inch thick. In some Porites of the same size, the whole mass is lifeless, excepting the exterior for a sixth of an inch in depth.

With such a mode of increase, there is no necessary limit to the growth of zoophytes. The rising column may grow upward, until it nears the surface of the sea, when death ensues simply from exposure, and not from any failure in its powers of life. The huge domes may enlarge till the same exposure just mentioned causes the death of the summit, and leaves only the sides to grow, which may increase indefinitely. Moreover, it is

evident that if the land supporting the growing coral were very gradually sinking, the upward increase of the coral might still be without limit.

There is hence sufficient means provided for the production of coral material for islands, however numerous. These humble ministers of creative power might, without other attributes than those they now possess, have laid the foundations of continents, and covered them with mountain ranges. This remark requires no limitation if we allow the requisite time, and connect with the power of growth such other agencies, soon to be explained, as have been at work in the Pacific since the reefs were there in progress.

The death of the polyps about the base of a coral tree would expose it seemingly to immediate wear from the waters around it, and especially as the texture is usually porous. But nature is not without an expedient to prevent a catastrophe that would be destructive to a large part of growing zoophytes, and would prevent the indefinite increase just explained. The dead surface becomes the resting-place of numberless small incrusting species of corals, besides Nullipores, Serpulas, and some molluscs. In many instances the lichen-like Nullipore grows at the same rate with the rate of death in the zoophyte, and keeps itself up to the very limit of the living part. The dead trunk of the forest becomes covered with lichens and fungi, or in tropical climes, with other foliage and various foreign flowers: so among the coral productions of the sea, there are forms of life which replace the dying polyp. The process of wear is thus entirely prevented.

The older polyps, before death, often increase their coral secretions within, filling the pores occupied by the tissues, and rendering the corallum more solid; and this is another means by which the trees of coral growth, though of slender form, are increased in strength and endurance.

The facility with which polyps repair a wound, aids in carrying forward the results above described. The breaking of a branch is no serious injury to a zoophyte. There is often some degree of sensibility apparent throughout a clump, even when of considerable size, and the shock, therefore, may occasion the polyps to close. But in an hour, or perhaps much less time, their tentacles will have again expanded; and such as were torn by the fracture will be in the process of complete restoration to their former size and powers. The fragment broken off, dropping in a favorable place, would become the germ of another coral plant, its base cementing by means of coral-secretions to the rock on which it might rest; or if still in contact with any part of the parent tree, it would be reunited and continue to grow as before. The coral zoophyte may be levelled by transported masses swept over by the waves; yet like the trodden

sod, it sprouts again, and continues to grow and flourish as before. The sod, however, has roots which are still unhurt; while the zoophyte, which may be dead at base, has a root—a source or centre of life—in every polyp that blossoms over its surface. Each animal might live and grow if separated from the rest, and would ultimately produce a mature zoophyte.

We close this review of the characters of coral animals, which is a mere abstract of the fuller descriptions in the General Report on Zoophytes, by alluding briefly to a second division of Zoophytes, not yet touched upon, and also to the Hydroidea and Bryozoa, which are likewise coral-making animals.

The Alcyonoidea.—The polyps of the Alcyonium* group of zoophytes differ from those which have been occupying us, in having but eight tentacles, and these are fringed with minute papillæ. The organ-pipe coral (Tubipora) is of this kind. When expanded in the sea, a clump resembles a bed of pinks, or looks like a lilac-cluster that had been dropped in the water; and this resemblance extends to the color and size of the flowers as well as their form.

Some of these zoophytes secrete lime and form a tube; and of this kind is the Tubipora. Others secrete only scattered granules of lime through the tissues: and still others are fleshy throughout. Many of them, besides forming granular calcareous secretions within the body of the polyp, give origin to a horny secretion at base, analogous to the epidermic secretions (hair, nails) of other animals; and this secretion receiving constant additions from the polyps as they are successively budded out, forms the axis of the growing branch. Of this character is the horny axis of the Gorgonia or sea-fan, which was long taken for a vegetable production. The crust which covers the axis consists of united polyps, which expand over its surface; and when expanded, each branch becomes a spike of flowers.

The Hydroidea.—The Hydroidea include the groups Hydra, Sertularia, Tubularia and the allied. Some species form thready tufts and plumes of extreme delicacy and others (the Hydræ) are simple polyps. The fine branchlets of the feathery species consist when dead of one or two series of microscopic cells arranged like tiny cups, tubes or goblets along the stem; and when alive, each cell is the site of a minute flower-animal. A coronet of tentacles surrounds the mouth, as in the Actiniæ, though somewhat different in character. The internal cavity is a simple tube without radiating lamellæ or special organs of reproduction, and the gemmules grow out singly or in bunches from the sides of the

* This name is derived from Alcyone, the fabled daughter of Neptune, and although from a Greek word having the aspirate breathing to the first letter, it was written by the Latins as here, (and by Linnæus and others,) without the H.

animal. The Hydra, an animal a line or two in length, consists of a tubular body, with a mouth at one extremity surrounded by a circle of tentacles: and the structure of the animal is so simple that it may be turned inside out, and still live and eat; it may be cut into forty or more parts, and from the dissected body, will grow as many distinct Hydræ. The Hydroidea are all minute and act no important part in reef-making.

The Hydroidea were long considered mature animals. But recent investigations have shown that part at least develop Medusæ, which are properly the adult individuals since these alone produce true ova. This division has therefore been recently removed from the zoophytes and placed with the Acalephs or Jelly-fishes.

The Bryozoa.—The Bryozoa are other coral-making species; but they are related to certain molluscs called Ascidiæ rather than to zoophytes. In habit and size they much resemble the Hydroidea. From a minute cabin-like cell, they extend a circlet of slender arms or tentacles, and expand into a delicate goblet-shape flower, seldom over a line in diameter. These polyps differ both from the Actinoidea and Hydroidea, in having two extremities to the alimentary canal—an anus, as well as a mouth; the intestine curves around and terminates in the disk. They are widely removed from true zoophytes, both by this character, and also by having the tentacles furnished with vibratile cilia—that is, minute appendages resembling short hairs, which are kept in nearly constant vibration.

Some species of Bryozoa form thin crusts over rocks or seaweeds, consisting of united cells, scarcely distinguishable unless magnified. The coralla of other species are branching or thin foliaceous; and these also consist of series of minute cells.

2. *Texture and Composition of Corals.*

The *texture* of calcareous corals is in general quite porous or cellular. Small stars or rounded depressions are scattered over the surface, and sometimes these stars form the centres of small prominences, called calicles (little cups). Besides these polyp-cells, which mark the position each of a separate polyp, there are pores or cellules penetrating the texture of the coral mass; yet in some zoophytes, the coral secretions continue increasing in the animal till the pores are almost or quite obliterated, and the texture is nearly compact, the polyp cells alone remaining. In many species, wherever there are concavities of much depth in the surface of a zoophyte, the coral of these concavities is looser or more spongy than elsewhere, for the reason, apparently, that the polyps in such parts have a poorer chance for securing food and fresh portions of water.

In the Gorgoniæ, and other species forming a distinct axis to the branches, this axis is solid, without a trace of a cell, and

usually with faint evidences of a concentric structure. It is thus that the red coral of commerce, used in jewelry, differs from the Madrepore or common white coral: it is the *axis* of a species of Corallium; and the polyps constituted a layer about it, in the same manner as the polyps of Gorgoniæ cover the horny axis of these species.

In *hardness*, the common calcareous corals are a little above ordinary limestone or marble, the degree being represented in the mineralogical scale of Mohs by 3·5 to 4, while, in limestone, it is about 3. The ringing sound given when coral is struck with a hammer, indicates this superior hardness. It is a common error of old date to suppose that coral when first removed from the water is soft, and afterwards hardens on exposure. But, in fact, there is scarcely an appreciable difference; the live coral has a slimy feel in the fingers; but if washed clear of the animal matter, it is found to be quite firm. The waters with which it is penetrated may contain a trace of lime in solution, which evaporates on drying, and adds slightly to the strength of the coral, but the change is hardly appreciable. A branched Madrepore rings on being struck when first collected; and a blow in any part puts in hazard every branch throughout it, on account of its elasticity and brittleness. Its *specific gravity* varies from 2·5 to 2·8: 2·523 was the average from fifteen specimens examined by Prof. B. Silliman, Jr.*

In *composition*, the common reef-corals, of which the branching Madrepora, and the massive Astræas are good examples, consist almost wholly of carbonate of lime, the same ingredient which constitutes ordinary limestone. In 100 parts, 90 to 96 parts are of this constituent; of the remainder, there are 3 to 8 parts of organic matter, with some earthy ingredients amounting in certain species to 2 parts, though often less than 1. These earthy ingredients are silica, magnesia, alumina, oxyd of iron, phosphate of magnesia, and fluorids of magnesium and calcium. The following is the result of one of Mr. Silliman's analyses from those made by him for the Report on Zoophytes.† The specimen was a Porites from the Sandwich Islands. It afforded—

Carbonate of lime, . . .	95·84
Phosphates, fluorids, &c., . .	2·05
Organic matter, ...	2·11

The various earthy ingredients are included in the second line of the analysis, in this species amounting to 2·05 per cent. One

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* Report on Zoophytes, page 713. On page 711, it is suggested by the author that the high degree of hardness, which characterizes corals and also the shells of many molluscs, may arise from the structure of the calcareous secretions being like that of arragonite, instead of common calc-spar. The hardness is near that of arragonite, though sometimes a little exceeding it.

† Op. cit., p. 712, and this Journal [2], i, 189.

hundred parts of the same, subjected to exact analysis, gave the following result:—

Silica,	22·00
Lime,	13·03
Magnesia,	7·66
Fluorid of calcium,	7·83
Fluorid of magnesium,	12·48
Phosphate of magnesia,	2·70
Alumina (and iron),	16·00
Oxyd of iron,	18·30

In other analyses similar results were obtained, with sometimes a larger proportion of fluorids.

The horny corals, (axes of Gorgoniæ and Antipathi,) were found by Hatchett to have nearly the constitution of ordinary horn.*

The sea-water and the ordinary food of the polyps are evidently the source from which the ingredients of coral are obtained. As coral is an animal secretion, there is no good reason for the surprise with which this subject is sometimes approached. The same powers of elaboration which exist in other animals belong to polyps; for this function, as we have remarked, is the lowest attribute of vitality.

Neither is it at all necessary to inquire whether the lime in seawater exists as carbonate or sulphate, or whether chlorid of calcium takes the place of these. The powers of life may make from the elements present whatever results the functions of the animal require.†

Various waters were collected in the vicinity of the coral islands, and at different distances from them, for the purpose of analysis in order to compare the constitution of the sea in different parts; but they were lost with the Peacock on the bar of the Columbia river. The proportion of lime salts which occurs in the water of the ocean is about $\frac{1}{30}$ to $\frac{1}{35}$ of all the ingredients in solution. Prof. Forchhammer has ascertained that around the West Indian seas, where corals abound, lime is not as abundant as elsewhere in the ocean, the proportion, according to five analy-

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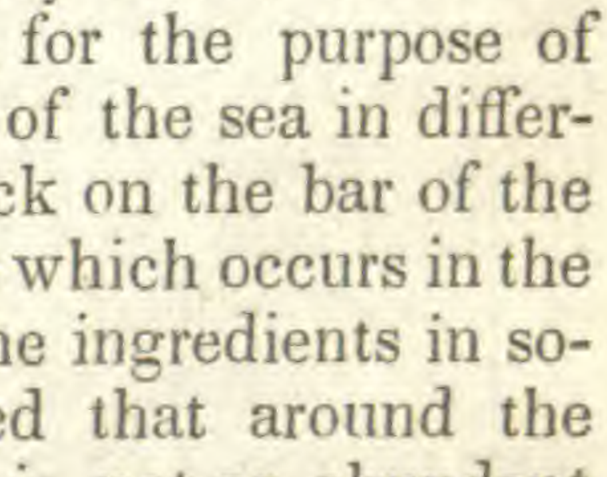
* Report on Zoophytes, p. 56.

† If a drop of sea-water be slowly evaporated under a microscope of high power, crystals of selenite (sulphate of lime) are produced, having the annexed forms, the most common presented by native crystals of this mineral, as stated in works on mineralogy. On adding more water, they are again dissolved; and this may be repeated indefinitely. These results would seem to indicate that the lime was mostly in the state of a sulphate.



Mr. Darwin states the remarkable fact, described by Mr. Webster, (Voyage of the Chanticleer, ii, 319.) that a deposit of salt and gypsum two feet thick occurs on the shores of Ascension, which was formed by the dash of the waves. Beautiful crystals of selenite were obtained by the writer in logs of half decomposed wood in the shore cliffs near Callao, which were of similar origin.

ses, being 247 to 10,000; while in the Kattegat, where the rivers of the Baltic carry it in considerable quantities, the proportion, from four analyses, is 371 to 10,000.* Schweitzer obtained the following result for water taken from the British Channel.†

	Grains.
Water,	964·74
Chlorid of sodium,	27·06
Chlorid of potassium,	0·77
Chlorid of magnesium,	3·67
Bromid of magnesium,	0·03
Sulphate of magnesia,	2·29
Sulphate of lime,	1·41
Carbonate of lime,	0·03
	1000·00

Recently, Mr. G. Wilson has detected fluorine in sea-water, showing that all the ingredients of coral are actually contained in the waters of the ocean.‡

It has been common to attribute the origin of the lime of corals to the existence of carbonic acid springs in the vicinity of coral islands. But it is an objection to such a hypothesis, that in the first place the facts do not require it; and in the second, there is no foundation for it. The islands have been supposed to rest on volcanic summits, thus making one hypothesis the basis of another. Carbonic acid springs are by no means a universal attendant on volcanic action. The Pacific affords no one fact in support of such an opinion. There are none on Hawaii, where are the most active fires in Polynesia; and the many explorations of the Society and Navigator Islands have brought none to light. Some of the largest reefs of the Pacific, those of New Holland and New Caledonia, occur where there is no evidence of former volcanic action.§

The currents of the Pacific are constantly bearing new supplies of water over the growing coral beds, and the whole ocean is thus engaged in contributing to their nutriment. Fish, molluscs, and zoophytes are thus provided with earthy ingredients for their calcareous secretions, if their food fails of giving the necessary amount; and by means of the powers of animal life, bones, shells, and corals alike are formed.

The origin of the lime in solution throughout the ocean is an inquiry foreign to our present subject. It is sufficient here to show that this lime, whatever its source, is adequate to explain all the results under consideration.

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* On Comparative Analytical Researches on Sea-water, by Prof. Forchhammer, —Rep. Brit. Assoc. for 1846, p. 90.

† Lond. and Ed. Phil. Mag. for July, 1839, xv, 51; Amer. Jour. Sci., xxxviii, 12.

‡ Trans. Roy. Soc. of Edinburg, xvi, 145, 1846; Am. Jour. Sci., 2d ser., ii, 114, 1846.

§ See also Darwin, op. cit., p. 60.

3. *Causes influencing the Growth of Coral Zoophytes.*

Marine zoophytes generally require pure ocean water, and they abound especially in the broad inner channels among the reefs, or the large lagoons, and in the shallow waters outside of the breakers. In these channels at the Feejee Group, there are species of every genus, and they grow in the greatest luxuriance, exceeding in profusion and display, all that was elsewhere seen in the Pacific. Here are found the huge Astræa domes, the Meandrinas, Porites, the leafy clusters of the Merulinæ, numerous Madrepores;—indeed nearly all the Pacific corals described in the Report on Zoophytes, exclusive of those from the Tahitian and Hawaiian Islands, were obtained from the inner reefs of the Feejees.* It is therefore an assertion wide from the fact that only smaller corals grow in the lagoons and channels, though true of lagoons and channels of small size, or of such parts of the larger channels as immediately adjoin the mouths of fresh-water streams.

There are undoubtedly species especially fitted for the open ocean; but as peculiar conveniences are required for the collection of zoophytes outside of the line of breakers, we have not the facts necessary for an exact list of such species. From the very abundant masses of Astræas, Meandrinas, Porites, and Madreporas thrown up by the waves on the exposed reefs, it was evident that these genera were well represented in the outer seas. In the Paumotus, the single individuals of Porites lying upon the shores were at times six or eight feet in diameter. Around the Duke of York's Island the bottom was observed to be covered with small branching and foliaceous Madrepores, (Manoporæ,) as delicate as any of the species in more protected waters.

Species of the same genera grow in the face of the breakers, and some are identical with those that occur also in deeper waters. Numerous Astræas, Meandrinas and Madreporas grow at the outer edge of the reefs where the waves come tumbling in with their full force. There are also many Milleporas and some Porites and Pocilloporas in the same places. But the weaker Manoporas, excepting incrusting species, are found in stiller waters either deep or shallow. The Nullipores, properly calcareous vegetation, flourish best along the line of breakers and form thick accumulations upon the reef.†

Again, the same genera occur in the shallow waters of the reef inside of the breakers. Astræas, Meandrinas and Pocil-

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* The author's observations on the *species* of corals were not commenced till reaching the Feejees, where we were among the *inner* reefs. Previous to that time, this department in Zoology was in the hands of Mr. J. P. Couthouy.

† Porites and Milleporæ, according to Mr. Darwin, prevail on the surf-reef of Keeling's Island. Chamisso states that the large Astræas live and grow in the breakers.

loporas are not uncommon, though requiring pure waters. There are also Madreporas, some growing even in impure waters. One species was the only coral observed in the lagoon of Honden Island (Paumotus), all others having disappeared owing to its imperfect connection with the sea. Upon the reefs enclosing the harbor of Rewa, (Viti Lebu,) where a large river three hundred yards wide empties, which during freshets enables vessels at anchor two and a half miles off its mouth to dip up fresh water alongside, there is a single porous species of Madrepora, (M. cribripora,) growing here and there in patches over a surface of dead coral rock or sand. In similar places about other regions, species of Porites are most common. In many instances, the living Porites were seen standing six inches above low tide, where they were exposed to sunshine and to rains; and associated with them in such exposed situations, there were usually great numbers of Alcyonia and Xeniæ. Porites also occur in the impure waters adjoining the shores; and the massive species in such places commonly spread out into flat disks, the top dying from the deposition of sediment upon it.

The exposure of six inches above low tide, where the tide is six feet, as in the Feejees, is of much shorter duration than in the Paumotus, where the tide is less than half this amount; and consequently the height of growing coral, as compared with low tide level, varies with the height of the tides. The powers of endurance in some coral zoophytes cannot surprise us, for it is well known that these animals are often very tenacious of life. The hardier species belong mostly to the genera Porites and Pocillopora, besides the family Alcyonidæ.

The small lagoons, when shut out from the influx of the sea, are often rendered too salt for growing zoophytes, in consequence of evaporation,—a condition of the lagoon of Enderby's Island.

Coral zoophytes sometimes suffer injury from being near large fleshy Alcyonia, whose crowded drooping branches lying over against them, destroy the polyps and mar the growing mass. But Serpulas, and certain species of barnacles constituting the genus Criseis, fix themselves upon the living Astræa, Millepora, and other corals, and finally become imbedded by the increase of the zoophyte, without producing any defacement of the surface, or affecting its growth. Many of these Serpulas grow with the same rapidity as the zoophyte, and finally produce a long tube, which penetrates deep within the coral mass; and, when alive, they expand a large and brilliant circle or spiral of delicate rays, making a gorgeous display among the coral polyps. Instinct seems to guide these animals in selecting those corals which correspond with themselves in rate of growth; and there is in general a resemblance between the markings of a Criseis and the character of the radiations of the Astræa it inhabits.

The effects of sediment on growing zoophytes are strongly marked, and may be often perceived when a mingling of fresh water alone produces little influence. We have mentioned that the Porites are reduced to flattened masses by the lodgment of sediment. The same takes place with the hemispheres of Astræa; and it is not uncommon that in this way large areas at top are deprived of life. The other portions still live unaffected by the injury thus sustained. Even the Fungiæ, which are broad simple species, are occasionally destroyed over a part of the disk through the same cause, and yet the rest remains alive. Wherever streams or currents are moving or transporting sediment, there no corals grow; and for the same reason we find no living zoophytes upon sandy or muddy shores.

The influence of *temperature* on the development of animal life, and the distribution of species is well known. But in no department is it more strikingly displayed than in that of zoophytes. In a former report we have considered the general influence of temperature on the several divisions of this order of animals. The remarks which follow are consequently confined to the *reef-forming* species. We reserve for still another page the influence of this cause on the distribution of reefs, since we are occupied here with zoophytes as animal species, and not with reefs, a result from the growth of corals.

The temperature of the ocean in which reef-corals grow is evidently the temperature congenial to them. From a general survey of facts, it appears that these species are not met with where the winter temperature remains much time below 66° F., though a temporary reduction to 64°, or perhaps lower, (as the Bermudas,) may sometimes occur. Where the temperature is above this, even in the hottest parts of the torrid zone, coral zoophytes thrive well. An isothermal line, crossing the ocean where this winter-temperature of the sea is experienced, one north of the equator, and another south, bending in its course by divergence or convergence, wherever the marine currents change its position, will include all the growing reefs of the world; and the area of waters may be properly called the *coral-reef seas*. This *limiting* temperature is found near latitude 28°. Under the equator in the Pacific, the waters where warmest, have the temperature 85° F., and in the Atlantic 83° F.; 66° to 85° is therefore not too great a range of temperature for the various reef-forming corals. Particular species, however, have smaller limits; but these limits have not yet been accurately ascertained.*

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* The first application of the well-established principle that temperature influences the growth and distribution of corals is claimed by Mr. J. P. Couthouy equally with myself. Any attempt, however, to determine a limiting temperature he disclaims, and in this particular, as well as the conclusions arrived at, our views are very different. The facts and inferences stated in this place, and on a following page, are deduced throughout from my own study and investigation.

The Porites and Pocilloporæ predominate at Oahu, (Sandwich Islands,) and there are but few of the Astræidæ,—a fact which appears to be explained on the ground that the reefs of that island are not far from the *cold* limits of the coral seas: and it is interesting to observe that these same corals are the hardiest under exposure to impure waters. The warmest parts of the ocean are favorable to the growth of Astræas, Meandrinas, and the allied species; and at the same time, these regions abound in Porites and Pocilloporæ, although the proportion of these corals is smaller than at Oahu.

The genera of reef-forming corals which occur out of the coral-reef seas, belong almost exclusively to the Caryophyllia family, and especially to the genera Dendrophyllia, Caryophyllia, Astroides,* Oculina, and Cyathina, some species of which exist in the Norwegian seas. The Gorgonidæ, Alcyonidæ, Hydroidea, and Actinidæ, extend from the equator nearly to the frigid zone. The Bryozoa have an equally wide range.†

The liability of the lagoons, when contracted in size, to become highly heated by the sun, is probably one cause leading to the depopulation of these internal waters. The temperature becomes raised, as in a puddle of standing water elsewhere, and is quite unfitted, therefore, for species accustomed only to the ordinary tropical temperature of the ocean.

Light and *pressure* and probably the amount of air in seawater, influence the growth of corals, so far as to fix limits to their distribution in *depth*. It is a little remarkable that those families which have a wide geographical range, have also a great range in depth: for Caryophylliæ, Dendrophylliæ, Oculinæ, Gorgonidæ, and Hydroidea, are found even at depths of one or two hundred fathoms; while Madrepores and Astræas, and all the ordinary reef-forming species scarcely exceed a depth of twenty fathoms.

Temperature has little or no influence in determining this range, although it has been so asserted: 66° is not met with under the equator short of 75 or 100 fathoms. The following table gives approximate results for the winter months, from observations on this point by different navigators in the Pacific. It is well known that these averages are varied much in particular regions by currents.

Latitude.		Depth of 6° Fahrenheit.
N. Latitude.	28°—30′	0—25 fathoms.
	25°	25—30 "
	20°	30—50 "

* The corals of the Astroides closely resemble those of the Astræa, and have been referred to the latter group by many authors. A related species is found on the coast of this country as high up as lat. 42. An Astræa has been reported from Sydney, New South Wales, which, if a true Astræa, (it has not been described or figured,) gives this genus a wider limit than the coral reef seas.

† See farther, Report on Zoophytes, p. 102.

	Latitude.		Depth of 6° Fahrenheit.
	15°	- -	40—60 fathoms.
	10°	- -	50—75 "
	5°	- -	75 "
Equator.	0°	- -	75—100 "
S. Latitude.	5°	- -	50—75 "
	10°	- -	50 "
	15°	- -	50 "
	20°	- -	40 "
	25°	- -	25 "
	28°—30°	- -	Surface.

It appears, therefore, that among the causes limiting the range of corals in depth, light and hydraulic pressure must have great influence. The proportion of atmospheric air present may be another cause. Yet according to Darondeau, the deeper waters contain more atmospheric air and also more carbonic acid,—the difference being as much as $\frac{1}{100}$th the volume of the water.*

Quoy and Gaymard were the first authors who ascertained that reef-forming corals were confined to small depths, contrary to the account of Forster and the early navigators. The mistake of previous voyagers was a natural one, for coral reefs were proved to stand in an unfathomable ocean; yet it was from the first a mere opinion, as the fact of corals growing at such depths had never been ascertained. It is now considered altogether probable that the bottom of the ocean in its deeper parts is mostly without life of any kind. The few Caryophylliæ and other species which are met with in deep waters, have been shown to be sparsely scattered, mostly of small size, and nowhere form accumulations or beds.

The above-mentioned authors, who explored the Pacific in the Uranie under D'Urville,† concluded from their observations that five or six fathoms (30 or 36 feet) limited their downward distribution. Ehrenberg, by his observations on the reefs of the Red Sea, confirmed the observations of Quoy and Gaymard; he concluded that living corals do not occur beyond six fathoms. Mr. Stutchbury, after a visit to some of the Paumotus and Tahiti, remarks that the living clumps do not rise from a greater depth than 16 or 17 fathoms.‡ Mr. Darwin, who traversed the Pacific with Captain Fitzroy, R. N., gives 20 fathoms as not too great a range, and mentions reported instances of growing reefs in 25 or even 30 fathoms. He states that in the Red Sea, according to Captain Morehead, living corals occur at 25 fathoms. At Keeling Atoll, growing corals are described by him as wholly disap-

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* Examination of Sea Water collected during the Voyage of the *Bonite*, Jameson's Edinb. Jour., July, 1838, p. 164. Darondeau's observations require confirmation.

† Afterwards also in the Astrolabe.

‡ S. Stutchbury, West of England Journal, i, 48.

pearing beyond 20 fathoms; and at the Maldives and Chagos, at a less depth. Other facts brought forward by Mr. Darwin, relate to Caryophylliæ and those species which have a wide range beyond reef-forming zoophytes.

It thus appears that all recent investigators since Quoy and Gaymard have agreed in assigning a comparatively small depth to growing corals. The observations on this point, made during the cruise of the Expedition, tend to confirm this opinion. The conclusion is borne out by the fact that soundings in the course of the various and extensive surveys afford no evidence of growing coral beyond twenty fathoms. Where the depth was fifteen fathoms, coral sand and fragments were almost uniformly reported. Among the Feejee Islands, the extent of coral reef-grounds surveyed was many hundreds of square miles, besides the more careful examination of harbors. The reefs of the Navigator Islands were also sounded out, with others at the Society Group, besides numerous coral islands; and through all these regions no evidence was obtained of corals living at a greater depth than 15 or 20 fathoms. Within the reefs west of Viti Lebu and Vanua Lebu, the anchor of the Peacock was dropped sixty times in water from 12 to 24 fathoms deep, and in no case struck among growing corals; it usually sunk into a muddy or sandy bottom. Patches of reef were encountered at times, but they were at a less depth than 12 fathoms. By means of a drag, occasionally dropped in the same channels, some fleshy Alcyonia, and a few Hydroidea were brought up, but no reef-forming species.

Outside of the reef of Upolu, corals were seen by the writer growing in twelve fathoms. Lieutenant Emmons brought up with a boat-anchor a large Dendrophyllia from a depth of fourteen and a half fathoms at the Feejees; and this species was afterwards found near the surface. Dendrophyllia, it may be remembered, is one of the deep water genera.

These facts, it may be said, are only negative, as the sounding-lead, especially in the manner it is thrown in surveys, would fail of giving decisive results. The character of a growing coral bed is so strongly marked in its uneven surface, its deep holes and many entangling stems, to the vexation of the surveyor, that in general the danger of mistake is small. But allowing uncertainty as great as supposed, there can be little doubt after so numerous observations over so extended regions of reefs.

The depth of the water in harbors and about shores where there is no coral, confirms the view here presented. At Upolu, the depth of the harbors varies generally from twelve to twenty fathoms. On the south side of this island, Lieutenant Perry, off Falealili, one hundred yards from the rocky shores, found bare rocks in eighteen and nineteen fathoms, with no evidence of coral. There is no cause here which will explain the absence of

coral, except the depth of water; for corals and coral reefs abound on most other parts of Upolu. Below Falelatai, of the same island, an equal depth was found, with no coral. Off the east cape of Falifa harbor, on the north side of Upolu, Lieutenant Emmons found no coral, although the depth was but eighteen fathoms. About the outer capes of Fungasar harbor, Tutuila, there was no coral, with a depth of fifteen to twenty fathoms; and a line of soundings across from cape to cape, afforded a bottom of sand and shells, in fifteen to twenty-one and a half fathoms. About the capes of Oafonu harbor, on the same island, there was no coral, with a depth of fifteen fathoms.

Similar results were obtained about all the islands surveyed, as the charts satisfactorily show. There is hence little room to doubt that twenty fathoms may be received as near the range in depth for reef corals; and probably the limit lies between fifteen and twenty fathoms, or not far from one hundred feet.

It may be here remarked, that soundings with reference to this subject are liable to be incorrectly reported, by persons who have not particularly studied living zoophytes. It is of the utmost importance, in order that an observation supposed to prove the occurrence of living coral should be of any value, that it be unequivocally determined whether the fragments which a lead may bring up are alive or not when broken off; for a dead fragment proves nothing. Even a strong impression upon the lead, showing the form and character of the surface-cells of a coral, is not wholly satisfactory, as it may have been given by a mass not living. A living fragment, placed in water, will be seen to have a fleshy surface, even if the polyps do not expand. The best observations with reference to this subject would be made with a diving bell.

Much yet remains for farther investigation. Mr. Edward Forbes, in his Zoological Explorations of the Ægean, distinguished three separate regions of invertebrate species within twenty fathoms of the surface: the *first*, or littoral, extending to two fathoms in depth; the *second* from two to ten fathoms; the *third* from ten to twenty fathoms.* Similar subdivisions, or others on the same general principle, may yet be detected in the Pacific, indicated perhaps by zoophytes as well as molluscs. There is no evidence, however, that there are successive beds, composed of a distinct set of species, as has been sometimes suggested. The upraised reefs of Metia afford no proofs of such a mode of formation; on the contrary, they show that the process is continuous and uniform in character through the reef-growing depths. The species in the lower part of the sixteen fathoms are probably different from many of those above; but they pertain to the same gen-

* On the Ægean Invertebrata, E. Forbes, Rep. Brit. Assoc. for 1843, p. 154.

era in most instances, and moreover there are no abrupt transitions; consequently the resulting reefs should have a nearly uniform character, as here stated. This fact may be better appreciated after perusing the following chapter.

The Nullipore zone along the reef-line between low and high tide, is clearly made out by Mr. Darwin, and is one of the interesting results of his investigations. It performs a very important part, by the protection it gives the reef from abrasion. The exposed reef is thus gathering lime from the waters, and extending itself, when, if devoid of this protection, it would be constantly yielding to the sea. On the inner reefs where the protection is not needed, it is not given; some species of Nullipore, however, occur in these regions, and others are found at various depths.

As the Caryophyllia family extend into deeper waters than most other reef-corals, it might be inferred that these at least may constitute a lower bed, or substratum. But this is by no means the case. As just stated, one species (the Dendrophyllia nigrescens) was found at 14½ fathoms and also of identical characters at low tide level. The Caryophylliæ are but sparingly distributed; the species are few, and mostly small; and not a dozen different kinds were detected in the Pacific. Their contributions to reefs are therefore inconsiderable.

4. *Rate of Growth of Zoophytes.*

The rate of growth of zoophytes, is a subject but little understood. We do not refer here to the progress of a reef in formation, which is another question complicated by many co-operating causes; but simply to the rapidity with which particular species of coral-zoophytes increase in size. There is no doubt that the rate is different for different species. It is moreover probable that it corresponds with the rate of growth of other allied polyps that do not secrete lime. The rate of growth of Actiniæ might give us an approximation to the rate of growth in a Mussa, which are coral animals of like size and general characters; for the additional function of secreting lime, would not retard necessarily the maturing of the polyp; and from the rate of growth of the same animals in the young state, we might perhaps draw some inferences as to the rate in polyps of corresponding size. But no observations on this point were made by us while abroad.

Although the rapidity is undoubtedly far less than was formerly reported, the following facts from different sources seem to show that the rate is still greater than has been of late believed. Mr. Darwin, citing from a manuscript by Dr. Allen of Forres, some experiments made on the east coast of Madagascar, states that, in December, 1830, twenty corals were placed by this gentleman apart on a sandbank, in three feet water, (low tide,) and

in the July following, each had nearly reached the surface, and was quite immovable; and some had grown over the others. Mr. Stutchbury describes a specimen consisting of a species of oyster, whose age could not be over two years, encrusted by an Agaricia, weighing two pounds nine ounces.* It is stated by M. Duchassaing, in a letter from Guadeloupe, that in two months, some large individuals of the *Madrepora prolifera*, which he broke away, were restored to their original size.†

Since the return of the Expedition, I have received a letter containing some facts on the growth of Actiniæ from Sir J. G. Dalyell, whose able observations in this department of science are highly curious and important. After speaking of the various conditions and sizes of the young at birth, and of the difference in the rapidity of growth depending on the amount of nutriment at hand, he says, speaking of a Scottish species of Actinia, "The dimensions will generally double in a fortnight from its birth. The diameter of the base being originally about an eighth of an inch, or hardly as much, will be five-eighths in six months, and the tentacles will occupy a circle of an inch and a half in diameter. In twelve or thirteen months, the diameter of the base will reach an inch and the expansion of the tentacles two inches between the tips. An Actinia whose tentacula expanded a quarter of an inch three weeks after it was produced, enlarged so much in five months that they expanded an inch, and the body was then half an inch thick." If we reason upon these data, and assume that the Madrepore polyps may increase lineally in six months as much as the young Actinia, we shall have an elongation of five-eighths or three-fourths of an inch in six months. Taking the still more rapid rate, of doubling in a fortnight, which might be more correct, since the Madrepore polyps are about the size of the Actinia in its earliest state, we should have a lengthening of a fourth of an inch in a month, and three inches a year. The data upon which this conclusion is based, though important, are uncertain, but would probably give too high rather than too low an estimate. And yet it is far below the rate apparently established by the experiments with corals cited in the preceding paragraph. We must admit that the subject requires more accurate investigation.

The stay of the expedition near any particular reef in the Pacific was too short for any examinations by us. They might easily be made by those residing in coral seas, either in the manner adopted by Mr. Allan, or more definitely by placing marks upon particular species. By inserting slender glass pins a certain distance from the summit of a Madrepore, its growth might be

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* West of England Journal, vol. i, p. 50,

† L'Institut, No. 639, April 1, 1846, p. 111.

accurately measured from month to month. Two such pins in the surface of an Astræa, would in the same manner, by the enlarging distance between, show the rate of increase in the circumference of the hemisphere; or if four were placed so as to enclose an area, and the number of polyps counted, the numerical increase of polyps resulting from budding, might be ascertained. It is to be hoped that some of the foreign residents at the Sandwich, Society, Samoan or Feejee Islands will take this subject in hand. There are also many parts of the West Indies, where these investigations might be conveniently made.

The applications of the facts reviewed occupy us in our next chapter.

ART. XX.—*On the Flow of Elastic Fluids through Orifices; with a suggestion of a new method of determining the mutual relations of Elastic Force, Temperature and Density in an Expanding Fluid;* by ELI W. BLAKE.

IN volume v, Second Series, of this Journal, page 78, I proposed a new theory of the flow of elastic fluids through orifices, differing essentially from that heretofore received. The chief object of the present article is to give an account of an experiment instituted for the purpose of testing the truth of that theory.

The fundamental points of difference between the old theory and the new, are as follows:—

1. The old theory regards the constant force which expels the fluid as being, in all cases, equal to the difference between the elastic forces of the fluids in the two vessels.

The new theory regards it as equal to that difference only when the less exceeds half the greater; and in all other cases as equal to half the greater.

2. The old theory considers the fluid as passing the orifice with a density equal to that in the *discharging* vessel.

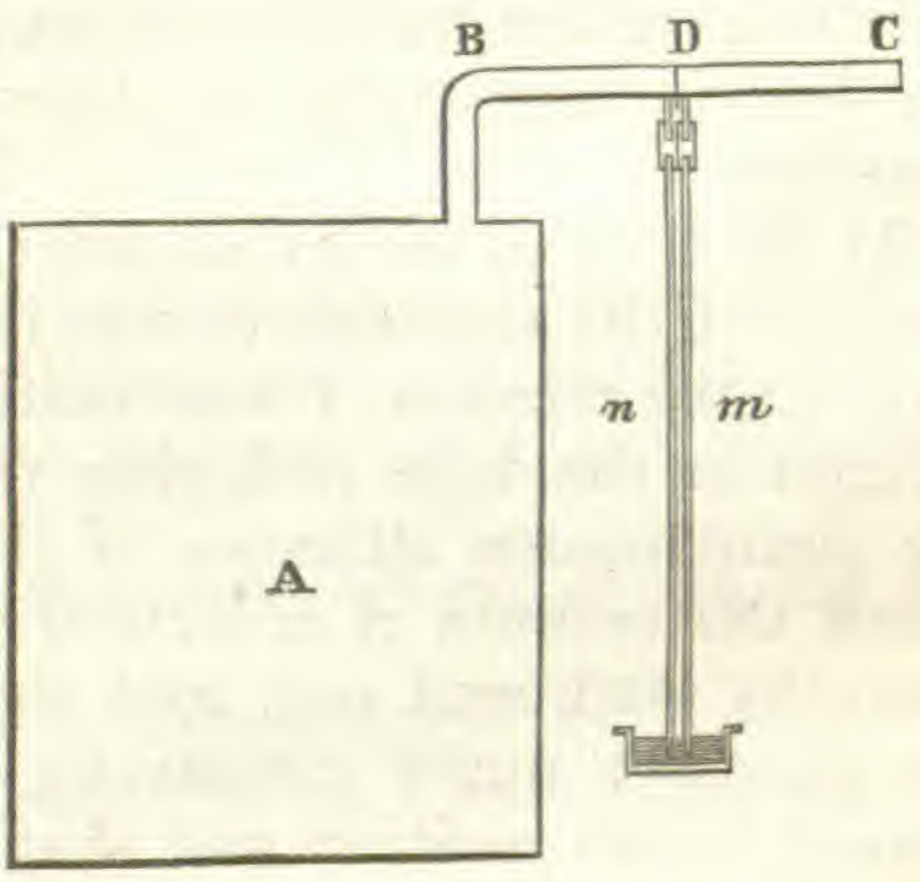
The new theory considers it as passing the orifice with a density equal to that in the *receiving* vessel, whenever this last is equal to or greater than half the density in the discharging vessel; and in all other cases, with half the density in the discharging vessel.

The formula for the quantity discharged in a given time, predicated upon the new theory, gives, in all cases, less than that predicated upon the old theory. In the case of a flow into a vacuum, the difference amounts to one half.

The scheme devised to test the relative merits of the two theories, was founded upon the following considerations, viz.: When air rushes from the atmosphere into a receiver wholly or partially exhausted, passing on its way through a small intermediate vessel or chamber, entering that chamber and passing out

of it through equal orifices, it will take in that chamber a density somewhere intermediate between that of the atmosphere and that in the receiver. For each relation that may at any moment subsist between the density of the atmosphere and that in the receiver, the density in the chamber will have a certain definite and determinate value, such that the chamber may receive through one orifice and discharge through the other simultaneously the same quantity of air. Now since in order to this equal simultaneous flow the two theories respectively demand quite different densities in the chamber, the object of my experiment was to ascertain the actual densities in such a chamber under various relations of the density in the receiver to the density of the atmosphere, in order to compare the densities thus ascertained experimentally with those demanded by each theory respectively in like circumstances.

To try the experiment, I constructed the apparatus shown in the annexed sketch. A is a vessel or receiver of the capacity of about 50 gallons, so arranged that it may be exhausted by the air-pump or otherwise. B is an elbow formed of lead pipe of one inch calibre, one branch of which opens into the receiver, and the end of the other branch at C is covered by a brass plate or disc about $\frac{1}{16}$th of an inch in thickness, through which is an orifice of about $\frac{1}{16}$th of an inch in diameter. Another similar plate with an orifice of the same size intersects the pipe at D, thus forming a chamber between the two plates. Two short tubes are inserted into the lower side of the pipe; one on each side of the plate D. With these short tubes two glass tubes *m* and *n*, each thirty-three inches in length, are connected by means of pieces of India rubber hose. These glass tubes are open at both ends and terminate at the bottom in a vase of mercury. A rod (not shown in the sketch) graduated to inches and tenths is placed beside the glass tubes, sustained upon a float resting upon the surface of the mercury, so adjusted that zero of the graduation may coincide with the surface of the mercury.



If the orifice at C be closed by a stopper and the receiver exhausted, the mercury will rise in the tubes; and if the density of the atmosphere at the time of the experiment be expressed in inches of mercury, the height of the mercury in the tubes as read upon the graduated rod will be equal to the difference between the density of the atmosphere and that in the receiver. If

we now remove the stopper from the orifice at C, the column of mercury in the tube *m* will instantly subside to a point which indicates the difference between the density of the atmosphere and the density in the chamber when an equal quantity of air flows through the two orifices; while at the same time the column of mercury in the tube *n* will only have *began* to subside very slowly as the density in the receiver increases. Having noted the height of the barometer at the time of the experiment, if we note the simultaneous heights of these two columns of mercury, and deduct them respectively from the height of the barometer, we shall have the density in the chamber necessary to an equal flow through the two orifices under the relation which subsists at the moment of notation between the density in the receiver and the density of the atmosphere. And if we note the simultaneous heights of these columns at various times during the filling of the receiver, so many densities in the chamber shall we find corresponding to different relations of the other two densities.

At the time of the experiment the height of the barometer, or density of the atmosphere was thirty inches. In consequence of leaks in the receiver, I was unable to exhaust it so as to raise the column in the tube *n* higher than twenty-six inches. I noted the simultaneous altitudes of the two columns at the moment when the column *n* coincided with each successive inch-mark upon the graduated rod, and thence ascertained the densities in the chamber under twenty-six different relations between the density in the receiver and that of the atmosphere. These results I have placed in the table beyond, in which the first column shows the densities in the receiver at the times of notation, and the second the densities in the chamber corresponding thereto.

In order to ascertain what these densities should have been according to the old theory, I constructed a formula as follows. Let Δ be the height of the barometer at the time of the experiment, D the density in the receiver, d the density in the chamber, V the velocity through the first orifice, v the velocity through the second orifice. Then according to the old theory the force which drives the air through the first orifice is $\Delta - d$ and that which drives it through the second orifice is $d - \mathrm{D}$. But since an equal quantity flows through both, these forces are as the velocities, that is $\Delta - d : d - \mathrm{D} :: \mathrm{V} : v$.

Again, according to the old theory the density with which the air passes the first orifice is Δ, and that with which it passes the second orifice is d. But since the orifices are equal and the quantities which pass through them are also equal, the products of the velocities by the densities are equal, that is $\Delta\mathrm{V} = dv$ and $\mathrm{V} = \frac{dv}{\Delta}$.

Substituting this value of V in the preceding couplet and then finding the value of d, we have the following formula for determining the densities in the chamber according to the old theory, viz.,

$$d=\sqrt{\Delta^2+\frac{\overline{\Delta-\mathrm{D}}|^2}{4}}-\frac{\Delta-\mathrm{D}}{2}.$$

The several densities in the chamber computed by this formula are placed in the fourth column of the table.

In order to ascertain what the densities in the chamber should have been according to the new theory, I constructed a formula as follows, preserving the same notation as above.

By the new theory the force which drives the air through the first orifice is $\Delta-d$ whenever d is not less than $\frac{\Delta}{2}$. But d is never less than $\frac{\Delta}{2}$ when an equal quantity flows through both orifices, for if it were so the chamber would, according to our theory, be receiving as much as could flow into a vacuum under the pressure Δ, and must therefore discharge into the receiver as much as would flow into a vacuum under a pressure Δ; in order to which the density in the chamber must be equal to Δ, and therefore greater than $\frac{\Delta}{2}$. Consequently, the force which drives the air through the *first* orifice is in this arrangement always $\Delta-d$. Again, the force expended in driving the air through the second orifice by the new theory is $\frac{d}{2}$ whenever D is not greater than $\frac{d}{2}$.

Let us first construct a formula for the cases in which D is not greater than $\frac{d}{2}$. In these cases the densities under which the air passes the orifices are respectively $\Delta-d$ and $\frac{d}{2}$. Since the forces are as the velocities, $\Delta-d:\frac{d}{2}::\mathrm{V}:v$; and since the quantities are equal, $d\mathrm{V}=\frac{dv}{2}$, and $\mathrm{V}=\frac{v}{2}$. Substituting this value of V in the couplet, we have $d=\frac{4}{5}\Delta$; a constant quantity. Hence while the density in the receiver varies from 0 to $\frac{2}{5}\Delta$, the density in the chamber is a constant quantity and equal to $\frac{4}{5}\Delta$. Let us now construct a formula for finding the value of d when D is greater

than $\frac{d}{2}$. In these cases the forces are $\Delta - d$ and $d - \mathrm{D}$ and we have for the couplet $\Delta - d : d - \mathrm{D} :: \mathrm{V} : v$. The densities in the orifices are d and D, and we have $d\mathrm{V} = \mathrm{D}v$ and $\mathrm{V} = \frac{\mathrm{D}v}{d}$. Substituting this last quantity in the couplet we find

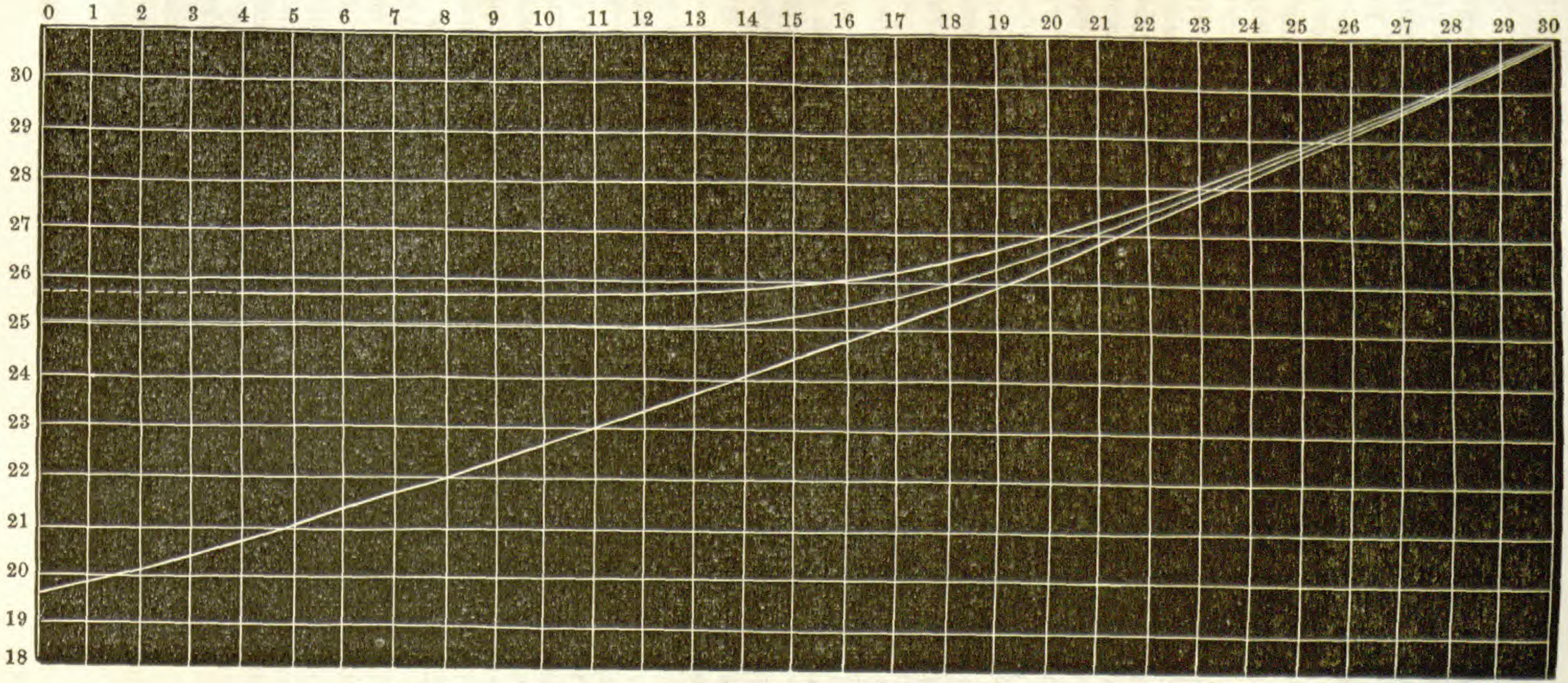
$$d = \sqrt{\mathrm{D}^2 + \frac{\overline{\Delta - \mathrm{D}}|^2}{4}} + \frac{\Delta - \mathrm{D}}{2}$$

as the formula for the value of d by the new theory when D exceeds $\frac{2}{5}\Delta$. The densities in the chamber computed by these formulæ are placed in the third column of the table.

Density of the Atmosphere during Experiment 30.

Density in the receiver.	Density in the chamber as found by experiment.	Density in the chamber due to the new theory.	Density in the chamber due to the old theory.	Deviation of the experiment from the new theory.
0		24	18·541	
1		24	18·820	
2		24	19·106	
3		24	19·397	
4	24·58	24	19·695	·58
5	24·58	24	20	·58
6	24·58	24	20·311	·58
7	24·58	24	20·628	·58
8	24·58	24	20·953	·58
9	24·58	24	21·284	·58
10	24·58	24	21·622	·58
11	24·60	24	21·968	·60
12	24·64	24	22·320	·64
13	24·70	24·032	22·713	·668
14	24·77	24·124	23·048	·646
15	24·89	24·270	23·423	·62
16	25·03	24·464	23·805	·566
17	25·21	24·700	24·194	·51
18	25·43	24·974	24·594	·456
19	25·69	25·280	25	·41
20	25·96	25·615	25·414	·345
21	26·30	25·976	25·835	·324
22	26·65	26·360	26·265	·29
23	27·03	26·764	26·699	·266
24	27·43	27·186	27·149	·244
25	27·81	27·625	27·604	·185
26	28·20	28·076	28·066	·124
27	28·65	28·541	28·533	·109
28	29·08	29·017	29·016	·063
29	29·55	29·504	29·504	·046
30	30	30	30	

The affinity of the experimental results to those derived from the new theory, is obvious upon inspection of the table; and the want of affinity to those derived from the old theory, is not less evident. The comparative relation of the two theories to the results of experiment, is more readily seen in the annexed cut,



Numbers at top represent the densities in the receiver; those on the side, densities in the chamber.

where they are respectively delineated by a curve. The upper curve represents the densities or elastic forces in the chamber, as found by experiment; the next curve those due to the new theory, and the lower curve those due to the old theory.

Notwithstanding the near approximation of the experimental results to those due to the new theory, there is yet a small but distinct deviation, which holds throughout. This deviation indicates either that there is some cause affecting the flow which the theory does not take into the account, *or* that in the structure of the apparatus or in trying the experiment, there was some failure to comply with the requisite conditions.

Although the apparatus was rude in its structure, yet care had been taken to secure a compliance with the conditions on which the experiment was based; and in conducting the experiment I was assisted by my friend, Prof. A. C. Twining, a gentleman distinguished for his accuracy in such matters. The experiment, moreover, was several times repeated, with no important difference in the results. For these reasons, in seeking the cause of the deviation, my first inquiry was whether it might be attributed to a change in the ratio of elastic force to density; the theory being predicated on the assumption that this ratio is constant. It has been ascertained by experiment, that when air is condensed and then suffered to lose the heat evolved by condensation, the ratio of its elastic force to its density will be diminished. Hence it is certain that a part or the whole, or possibly even more than the whole heat evolved by condensation will be required to prevent that ratio from being diminished. Still, however, it has generally been assumed by philosophers (I know not on what grounds) that if air is *suddenly* condensed, so as not to allow the heat evolved by condensation to escape, the ratio of elastic force to density will be *increased*. This assumption was made by Laplace when he attributed to this cause, in part, the velocity of sound. Let us suppose then, for the present, that in sudden condensation the ratio of elastic force to density is *increased*. It will then follow that in sudden *expansion*, the ratio of elastic force to density will be *diminished*. But if that ratio were diminished, then the deviation in the table should be in the opposite direction; that is, the experimental results, instead of being greater than the theoretical, should be less. The deviation, therefore, is not accounted for by this supposition; on the contrary, the experiment seems to prove that the ratio is not diminished by expansion, and therefore cannot be increased by condensation, as Laplace supposed.

Let us next take the contrary supposition, viz., that the ratio of elastic force to density is *increased* by expansion. This would cause a deviation in the same direction as we find in the table. In order to ascertain whether the deviation in question is due to this cause, we must next inquire whether a deviation arising from

this cause, would vary in the same manner throughout the table, as does the observed deviation. Now if we go through the table and assign for each observation severally, the manner in which the ratio of elastic force to density must increase, in order to satisfy that observation, we shall find very nearly one and the same increment of the ratio demanded for all the observations. Hence if we attribute the deviation to this cause we should be obliged to conclude that one and the same change in the ratio takes place, whether the expansion be greater or less. But such a conclusion is obviously inadmissible. We cannot, therefore, attribute the deviation in question to a change in that ratio, either by increase or diminution.

Nor can we ascribe the deviation to that which is the chief cause of deviation from theory in the case of the flow of *liquids*, viz., the contraction of the stream in passing an orifice. For if that cause operated, it would affect the flow in the same ratio in both orifices, and therefore would not, in this case, affect the indications of the mercurial columns. Moreover, I think it can be shown, from considerations *a priori*, that the cause which produces the contraction of the stream in liquids, could not operate to affect the flow of expansible fluids.

Having satisfied myself that the deviation was not due to the causes above named, my next inquiry was, whether a difference in the sizes of the orifices (hitherto assumed to be equal) would cause a deviation corresponding to that in the table. In examining this point, I found that the experimental results would be very nearly satisfied throughout the table, by the assumption that the area of the second orifice was less than that of the first, in about the ratio of ·933 to 1. As the two orifices had been made as nearly equal as they could be by forcing the same steel plug through both, I was confident that, as originally formed, they could not differ to this extent. But it occurred to me that some accidental circumstance might have occurred to diminish the inner orifice, and I suspected that the workman, in handling the brass plate after the orifice was made, had got dirt into it, and had omitted to cleanse it before soldering on the outer plate. To ascertain whether such was the case, I divided the tube near the second orifice, and, upon examining it with a microscope, discovered that there was dirt adhering around its inner periphery sufficient, I think, to cause a diminution of its area to the extent above named. Unfortunately this discovery was made after the arrangements for trying the experiment had been removed; and I have not since found leisure to replace them and try the experiment anew. But for this accidental circumstance no doubt there would have been a still nearer approximation of the experimental results to those derived from the formula. The coincidence, however, is sufficiently near to establish the truth of the new

theory, so far as respects those points of difference between the two theories specified in the first part of this article.

The fifth column of the table shows the several differences between the experimental results, and those due to the new theory. It will be noticed that these differences increase slightly between density 10 and 13 in the receiver, before they begin to decrease. This, I think, indicates a slight obstruction to the flow through the second orifice, when the density in the receiver becomes equal or nearly equal to that of the effluent stream. This increment at its maximum amounts to ·088, corresponding to the pressure of that portion of an inch of mercury, and is, I think, the measure of the obstruction or resistance due to that circumstance. If this view of the subject is correct, then there would have been a deviation to this extent in this part of the table, even if the orifices had been equal.

It is desirable that further experiments of this kind should be tried by those who have better means at command than I had to do justice to the subject. To such as may be disposed to undertake it, I would suggest that a perfect equality of the two orifices might be secured by interchanging the discs, varying the sizes of the orifices until they gave the same indications in both positions.

If, after thus securing the equality of the orifices, there should still be a deviation in that part of the table where the elastic force in the chamber is constant, such deviation, I think, must be attributed to a change in the ratio of elastic force to density; and if so, its amount would furnish the means of determining the law according to which that ratio varies.

I would also suggest that a modification of this experiment would furnish perhaps the best possible means of determining the law according to which the ratio of elastic force to *temperature* varies, when the absolute amount of heat is constant. In an arrangement for this purpose, the bulb of a thermometer should be inserted into the chamber; and the outer orifice should be so constructed that it may be enlarged or diminished at pleasure. With this arrangement, we may cause the air in the chamber to assume, almost instantly, any elastic force we may choose, between the elastic force of the atmosphere, and a little more than twice the elastic force in the receiver; and we may keep that force *constant* in the chamber during any time that may be required to cool the thermometer down to the corresponding temperature, the continual flow through the chamber in the mean time carrying off not only the heat which flows in from extraneous sources, but also that derived from the thermometer itself. We may thus ascertain the relation of elastic force to temperature at as many points as we please within this range, and thereby determine the law of their variation when the absolute amount of heat remains constant.

Art. XXI.—*On the Relation of the Chemical Constitution of Bodies to Taste;* by Prof. E. N. Horsford, of Harvard.*

Prof. Horsford alluded to a paper upon Glycocoll published in 1846, in which he called attention, in a note, to the interesting relation sustained by that body in its chemical constitution, to other sweet bodies, and cited the following formulæ:

$C_4H_3\overset{H}{\underset{N}{}}O_3$ = Glycocoll. $C_4H_3\overset{H}{\underset{O}{}}O_3 \times 3$ = Grape sugar.

$C_4H_3\overset{Pb}{\underset{O}{}}O_3$ = Sugar of lead. $C_4H_3\begin{matrix}H\\H^{\frac{2}{3}}\end{matrix}O_3$ = $\frac{2}{3}$ Oxyd of glycerile $\begin{matrix}\\O^{\frac{1}{3}}\end{matrix}$

To this enumeration of sweet bodies was appended the query, "Is this similar taste dependent upon a similar arrangement of their minutest particles?"

Prof. H. remarked that, early in 1848, he presented to the American Academy of Arts and Sciences, with a modification of the formulæ, an additional list of sweet bodies. Some of the formulæ were arbitrarily doubled from the received fromulæ, and others fractionally reduced, for the sake, merely, of tracing this interesting relationship.

The modification of the formulæ, and the list as then presented, were as follows:

$C_4H_4O_4 \times 3$ = Grape sugar.

$C_4H_2\overset{H}{\underset{O}{H}}O_3$ = Grape sugar. $C_4H_2\overset{H}{\underset{N}{H}}O_3$ = Glycocoll.

$C_4H_2\overset{Pb}{\underset{O}{H}}O_3$ = Sugar of lead. $C_4H_2\overset{Pb}{\underset{O}{H}}O_3 \cdot 3$ = Citrate of lead.

$C_4H_2\overset{K}{\underset{O}{H}}O_3$ = Acetate of potassa. $C_4H_2\overset{H}{\underset{N}{H}}O_3, H, O,$ = Nitric ether,

$C_4H_2\begin{matrix}H\\H\\H^{\frac{2}{3}}\end{matrix}O_3 \times 1{\cdot}5$ = Oxyd of glycerile. $\begin{matrix}\\\\O^{\frac{1}{3}}\end{matrix}$

$C_4H_2\overset{Cl}{\underset{Cl}{Cl}}Cl_3 \div 2$ = Chloroform. $C_4H_2\overset{Br}{\underset{Br}{Br}}Br_3 \div 2$ = Bromoform.†

$C_4H_2\overset{I}{\underset{I}{I}}I_3 \div 2$ = Iodoform. $C_4H_2\overset{I}{\underset{Cl}{Cl}}Cl_3 \div 2$ = Chloroiodoform.

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* Proceedings of the American Association for the Advancement of Science. Fourth meeting, held at New Haven, Conn., August, 1850.

† For the observation that this and the following four bodies may be included under this type, the author acknowledged his indebtedness to his assistant, Dr. Chas. H. Peirce.

$$C_4H_2\overset{Br}{\underset{I}{Br}}I_3 \div 2 = \text{Bromoiodoform.}$$

$$C_4H_2\overset{H}{\underset{H}{H}}\overset{H}{F_2} \div 2 = \text{Hydrofluate of methylene.*}$$

$$C_4H_2\overset{S}{\underset{S}{S}}S_3 \div 2 = \text{Sulphoform.}$$

$$C_4H_2\overset{H}{\underset{H}{H}}\overset{H}{Cl_2} \div 2 = \text{Chlorid of methyle.}$$

$$C_2S_2H_2Ag\overset{O}{\underset{O}{}}O_3, H, O, = \text{Methylsulphite of silver.}$$

$$C_2S_2H_2Pb\overset{O}{\underset{O}{}}, H, O, = \text{Methylsulphite of lead.}$$

$$C_2S_2H\overset{O}{\underset{O}{Cl}}AgO_3, H, O = \text{Chloro-methylsulphite of silver.}$$

$$C_2S_2H\overset{O}{\underset{O}{Cl}}PbO_3, H, O = \text{“ “ lead.}$$

$$S_4Ag_2\overset{O}{\underset{O}{O}}O_3 \div 2 = \text{Hypo-sulphite of silver.}\dagger$$

$$S_4\overset{Na}{\underset{Hg}{O}}\overset{O}{\underset{O}{}}O_3 = \text{Hypo-sulphite of mercury and soda.}$$

To these Prof. Horsford remarked there might be added

$$C_4H_2\overset{H_2}{\underset{O}{}}O_3 \cdot 3 + H_2 = \text{Mannite; and}$$

$$C_4H_4S_4.$$

Several other compounds of sulphur with C_4H_4 do not taste sweet.

The following sweet bodies, one possessing a multiple and the other nearly a multiple of the number of atoms in glycocoll, do not readily admit of being written in the above formula—

$$C_{10}H_{11}O_3 = 24 = \text{Valerianic acid.}$$
$$C_{16}H_{11}O_7 = 34 = \text{Orcine.}$$

In reply to the inquiry as to whether sweetness may be ascribed to a peculiarity of form, the following facts are of significance:

$C_4H_4S_4$	tastes sweet,	and contains	C, H and S.
$C_4H_4O_4$	“	“	C, H and O.
$S_4\overset{O_2}{\underset{Ag_2}{}}O_4$	“	“	neither C nor H.

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* This body has a pleasant ethereal smell.

† The correspondence in constitution of this body with the next in succession gives additional interest to the formula.

The taste is, therefore, not dependent upon any one of the elements present, since each may be replaced entirely by another without destroying the taste.

In the communication submitted to the American Academy, attention was directed to the common formula, in which, according to Davy and to most modern chemists, all the acids containing hydrogen may be written, and also the oxygen acids which ordinarily exist in combination with an atom of water, as sulphuric and nitric acids; to wit, $H + x$; in which x represents all that part of the acid not replaced by metal in neutralization. A few examples follow:

$H + Cl$	= Hydrochloric acid.	$H + NO_6$	= Nitric acid.
$H + I$	= Hydriodic "	$H + C_2HO_4$	= Formic "
$H + Br$	= Hydrobromic "	$H + C_2O_4$	= Oxalic "
$H + F$	= Hydrofluoric "	$H + C_4H_3O_4$	= Acetic "
$H + Cy$	= Hydrocyanic "	$H + C_6H_5O_4$	= Metacetonic acid.
$H + SO_3$	= Sulphurous "	$H + C_8H_7O_4$	= Butyric "
$H + SO_4$	= Sulphuric "	$H + C_{10}H_{11}O_4$	= Valerianic " &c.

The inquiry naturally arises, have sour bodies a common *form?* to which, and not to the nature of the constituent particles, the property of sourness is to be attributed. They (the acids) are composed of one larger atom, or group of atoms united to the least atom, hydrogen, easily replaceable by a metal, and bound to the group by an affinity apparently much feebler than that of any of the remaining elements.

An allusion was made, in the communication to the Academy, to the class of resins—some of the soluble members of which possessing a bitter taste—might, according to a research of Heldt upon Santonine, be referred to a single fundamental type. He refers the resins, for their origin, to the oxydation of the essential oils, and though the conception has been entertained by other chemists, it has first met with a full exposition in this paper. The hydrogen of essential oils oxydates, as a general thing, much more readily than the carbon. The following formulæ present Heldt's view of the production of resins. All are derived, he conceives, from $C_{10}H_8$.

$$[C_{10}H_8]^n - Hx + Ox = R.$$
$$[C_{10}H_8]^n - Hx + Ox + (HO)y = R.$$
$$[C_{10}H_8]^n - Hx + Ox + Oy = R.$$
$$[C_{10}H_8]^n - Hx + Ox + Oy = [HO]z = R.$$
$$[C_{10}H_8]^n + [HO]x = R.$$

These formulæ present in the original essential oils, groups of atoms, in which a part of the hydrogen occupies a more exposed situation, if one may employ the illustration, than other parts of the molecule, and oxydates more readily. In this respect there is approximation to a common form, in view of which the in-

quiry was suggested, *may the bitterness be ascribed to this form?* This, however, does not furnish an explanation of the remarkable bitterness of the organic bases.

Guided by the above suggestion, Prof. H. remarked, let the conception be entertained that the alkaloids have been derived from the greater or less oxydation of bodies having the general constitution of the essential oils, and the replacement of three atoms of water with one atom of ammonia for every atom of nitrogen contained in the organic base. The corresponding replacement of ammonia with three atoms of water is not of unfrequent occurrence in organic chemistry.

Upon the speculation that this has been the derivation of the alkaloids, it will be easy to convert them into the essential oils from which they were derived. If we halve the formula of the oil, the first of Heldt's formulæ gives

$$(C_5H_4)^n - Hx + Ox = R.$$

A certain number of atoms of hydrogen deducted from, and an equal number of atoms of oxygen added to, n times C_5H_4 constitute the resin. If, in adding nitrogen, we deduct for each atom of nitrogen three atoms of oxygen, or, which is the same thing, for each atom of ammonia (NH_3) added, deduct three atoms of water, we have an organic body containing C, H, N and O, a body corresponding in constitution with an alkaloid.

By reversing this process, we may convert the alkaloid into its corresponding essential oil.

Take for example Papaverin, one of the alkaloids of opium, analyzed by Merck, $C_{40}H_{21}NO_8$.*

Three atoms of oxygen for the atom of nitrogen, united to the eight atoms of oxygen, making eleven in all, correspond with eleven atoms of hydrogen, which, added to the twenty-one present, make thirty-two.

$$C_{40}H_{21}NO_8 - N - O_8 + H_8 + O_3 = C_{40}H_{29} + O_3,$$

which correspond with

$$C_{40}H_{32} = (C_5H_4)^8.$$

There is doubt still resting upon the constitution of most of the alkaloids. Of those considered as best established, the following examples will be sufficient for a practical illustration of the above speculation.

Thebain $= C_{25}H_{14}NO_3 = C_{25}H_{20} = (C_5H_4)^5$.
Furfurin $= C_{30}H_{12}N_2O_6 = C_{30}H_{24} = (C_5H_4)^6$.
Codein $= C_{35}H_{20}NO_5 = C_{35}H_{28} = (C_5H_4)^7$.

The formula $(C_5H_4)^n - Hx + Ox + Oy = R$, is suited to the derivation of Bebeerin.

$$C_{35}H_{20}NO_6 = C_{35}H_{29} = (C_5H_4)^7 + H.$$

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* Liebig's Ann., lxvi, 125; Pharm. Contr., 1848, 930.

Harmalin requires the addition of C_2H_2 to the second of Heldt's formulæ $(C_5H_4)^n - H_x + O_y = R$.

$$C_{27}H_{14}N_2O_2 = C_{27}H_{22} = (C_5H_4)^5 + C_2H_2.$$

Chinin and Cinchonin require the subtraction of C_2.

$$\text{Chinin} = C_{38}H_{22}N_2O_4{}^* = C_{38}H_{32} = (C_5H_4)^8 - C_2.$$
$$\text{Cinchonin} = C_{38}H_{22}N_2O_4{}^\dagger = C_{38}H_{32} = (C_5H_4)^8 - C_2.$$

Strichnin requires the deduction of an atom of carbonic acid, or its equivalent CH_2, and the same formula of resin as that of Bebeerin.

$$C_{44}H_{24}N_2O_4 = C_{44}H_{34} = (C_5H_4)^9 - CH_2.$$

Cotarnin requires the addition of an atom of carbonic acid.

$$C_{26}H_{13}NO_6{}^\ddagger = C_{26}H_{22} = (C_5H_4)^5 + CH_2.$$

The following require slight modifications.

$$\text{Morphin} = C_{34}H_{19}NO_6{}^\S = C_{34}H_{28} = (C_5H_4)^7 - C.$$
$$\text{Piperin} = C_{34}H_{19}NO_6{}^\| = C_{34}H_{28} = (C_5H_4)^7 - C.$$
$$\text{Veratrin} = C_{34}H_{22}NO_6 = C_{34}H_{31} = (C_5H_4)^7 - C + H_3.$$

It will readily be seen that in this series the differences between the essential oil and its derivative are such as would disappear with the addition or subtraction of an atom of carbonic acid, or water in some cases, and a little more or less oxydation in others.

In those bases where the quantity of nitrogen is much larger, the third formula of Heldt would still give us the corresponding resins.

$$(C_5H_4)^n - H_x + O_x + O_y = R.$$

Take for example Caffein.

$$C_{14}H_8N_4O_4.$$

The nearest essential oil of the constitution $(C_5H_4)^n$ is $C_{15}H_{12}$.

$$C_{15}H_{12} - H_4 + O_4 + O_{14} + 4(H_3N) - 12HO = C_{15}H_8N_4O_6.$$

If we deduct from this formula an atom of carbonic acid, we have

$$C_{15}H_8N_4O_6 - CO_2 = C_{14}H_8N_4O_4.$$

Theobromin differs, as has been remarked,¶ from Caffein only by C_4H_2.

$$C_{14}H_8N_4O_4 + C_2H_2 = C_{16}H_{10}N_4O_4.$$

The construction from the class of oils, above referred to, of the formulæ of those alkaloids in which the quantity of hydrogen is much greater, is more difficult.

The foregoing relationships have an interest taken in connection with the inquiry to which attention has been directed, to wit, *May there be a common form among bodies having a common taste?*

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* Ann. Ch. Phys. [3] xix, 363; Ann. d. Ch. u. Phar., lxii, 95.
† Ann. Ch. Phys. [3] xix, 365. ‡ Ann. Ch. Phys. [3] xix, 370.
§ Ann. Ch. Phys. [3] xix, 361; Ann. d. Ch. u. Phar., lxiii, 98.
‖ Ann. Ch. Phys. [3] xix, 363.
¶ Ann. d. Ch. u. Pharm., lxi, 338? Pharm. Cont. Blatt., 1847, 424.

Art. XXII.—*Foucault's Pendulum Experiment.*

The peculiar interest of Foucault's experiment with the Pendulum, by which the rotation of the earth is proved even within the walls of an ordinary lecture room, has obtained for it very general attention, and it has already been repeated in numerous places in this and other countries. The occurrence from which M. Foucault was led to his discovery is thus related by him.* "Having fixed on the arbor of a lathe and in the direction of the axis, a round and flexible steel rod, it was put in vibration by deflecting it from its position of equilibrium and leaving it to itself. A plane of oscillation is thus determined, which, from the persistence of the visual impressions, is clearly delineated in space. Now it was remarked that on turning around with the hand, the arbor which formed the support of this vibrating rod, the plane of oscillation was not carried with it, but always retained the same direction in space." From this came the conclusion that a pendulum set in motion will continue in the same plane of vibration, however the point of suspension be rotated—a fact easily proved by a simple trial with a weight at the end of a cord. The rotation of the point of suspension may make the pendulum revolve on its axis; but the plane of vibration will remain the same. The reason for this is obvious: the swinging pendulum, when about to return (after an outward swing) from its point of rest, is made to move from that point by gravity alone, and can therefore fall but *in one direction;* and the momentum acquired by falling carries it beyond this centre in the *same* direction to the point of rest on the other side; here again it is in a like condition, and must return under the force of gravity in one and the same line, gravity acting in the same direction whether the point of suspension be rotated or not. Thus the plane of vibration is fixed from the very nature of the forces at work.

It is evident, therefore, that if a pendulum were swinging at the pole of the earth, the plane of vibration, as it would not change with the revolution of the earth, should mark this revolution by seeming to revolve in the contrary direction, and in 24 hours it would make *apparently* the whole circuit of 360 degrees. But at the equator, the plane of vibration is carried forward by the revolution of the earth, and so undergoes no change with reference to the meridians. Between the equator and poles, the time required for the pendulum to make 360° varies according to the latitude, being greater the farther from the pole. For these intermediate latitudes the problem is beautifully solved on a globe.

Having a globe for the trial, select, for instance, latitude 30°, and apply the principle that the plane of vibration is constant

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* Bibl. Universelle, March, 1851.

notwithstanding the revolution. Suppose the plane of vibration to be the meridian of Greenwich: draw a series of lines across the parallel of 30°, parallel to this meridian; each of these lines will show precisely the position of the pendulum, in the revolution, at the point where the line intersects the parallel of latitude. If, for example, we draw one of these parallel lines across the intersection of 30° with the *first* meridian circle east of Greenwich; another across the intersection of the parallel of 30° with the *second* meridian; another across the *third*, and so on;—each will mark the position of the plane of vibration after a revolution of as many degrees as are included between the meridians. Continuing this on, the parallel lines become more and more easterly, and finally they are exactly east and west in longitude 180°; or in other words, the plane of vibration, which is still parallel to the Greenwich meridian, is actually at right angles to the meridian of 180°; this plane has therefore changed apparently 90°, while the earth was revolving 180° or making half its circuit. And if this be continued, it will be found that the parallel lines will make the whole circuit of 360° in twice the earth's revolution, or what is equivalent, in 48 hours.

These parallel lines drawn on the globe, it is to be observed, should be parts of great circles, and are strictly parallel to one another only at the intersections with the parallel of latitude, like the meridians where they cross the equator; their tangents at these intersections will be actually parallel throughout, like the tangents to the meridians at the equator, and these tangents represent the true angle of the plane of vibration.

Again take latitude 70°, and in the same manner draw lines parallel to the meridian of Greenwich, going eastward. These parallel lines will rapidly diverge from the meridian, the divergence being nearly $9\frac{1}{2}$ degrees for every 10 degrees of longitude; in lon. 95° $46\frac{1}{2}'$ E. the intersecting line will point east and west, having made 90° in its apparent revolution. In 191° 33′ it will have made 180°, and in 383° 6′, (or 23° 6′ east of the meridian of Greenwich,) it will have completed the whole 360°; so that in latitude 70° the time of the apparent revolution of the plane of vibration, is a little over $25\frac{1}{2}$ hours. The globe thus exhibits to the eye the actual uniform position of the plane of vibration, and at the same time its apparent revolution. By marking these parallel lines at one end with an arrow-head, and also describing an arc with the point of intersection as a centre, the increasing divergence from the meridians, and the apparent rotation by east, south, and west to north, is well shown.

If now tangents be supposed to be drawn to each meridian circle, at its intersection with any parallel of latitude, say that of 70°, these tangents will intersect at a point in the axis of the earth extended; and the angle included between any two such

tangents is the angle which the corresponding meridians make with one another in the given latitude. The plane of vibration, since it continues parallel to itself, will therefore change with reference to the meridians, just the amount of the angle included between these tangents. This is readily seen on the globe, marked off as above explained, in which the Greenwich meridian is the starting point. The angle which one of the parallel lines drawn on the globe (or its tangent) makes with the meridian it intersects is (from the nature of parallel lines) equal to the angle between the tangent to this meridian and that of Greenwich. The sum therefore of the angles between all the tangents to the meridians, will be the amount of apparent variation in the plane of vibration for 24 hours. These tangents—which are strictly the cotangents of latitude—form together the surface of a cone whose base is the parallel of latitude, and whose angle of surface at summit is equal to the revolution of the pendulum in 24 hours. If this cone be supposed to be cut open and laid out on a flat plane, it will form a sector of a circle, whose angle at the centre equals the angle around the apex of the cone. The radius of this sector (or of its circle) equals the cotangent of latitude, (*cot L*); and the circumference of the sector is actually a parallel of latitude—a parallel of latitude having been the base of the supposed cone. Now as the number of degrees in any arc varies with the length of the arc as related to the radius of the circle, or as $\frac{arc}{R}$; and since the *arc* here is a parallel of latitude and these parallels vary with the cosine of latitude (*cos L*), and since also the radius (*R*) equals *cot. L* —it follows that the number of degrees in the arc (or the number expressing the apparent motion of the plane of vibration for 24 hours,) will vary as $\frac{cos\ L}{cot\ L}$, an expression equivalent to the *sine* of latitude.

Other demonstrations arrive at the same result, but none is more simple or more conclusive.

The theory thus involves no necessary consideration of the forces engaged, by which many explanations of the experiment are encumbered, but is simply a geometrical problem, based on the position of the meridians of a revolving sphere, and the fact that the pendulum moves in a fixed direction, parallel to the meridian in which it is started.

The idea involved in Foucault's experiment "seems to have occurred long ago, and is mentioned in a paper in the Phil. Trans. 1742, No. 468, by the Marquis de Poli, in the course of some observations on the pendulum of a different kind. He remarks, 'I then considered (adopting the hypothesis of the earth's motion,) that in one oscillation of the pendulum there would not be de-

scribed from its centre perfectly one and the same arc in the same plane'; but he does not pursue the subject as being foreign to his immediate object."* It appears also, (Comptes Rendus, 1851, No. 6,) that in 1837, Poisson had hinted at such an effect, but supposed it of insensible amount.

Different modes of varying the experiment have been proposed. The following is suggested by Poinsot. If two balls are suspended in contact, with a spring between them, and then by a sudden action of the spring are thrown apart and thus held by some attached contrivance, they will retain, after the change of position, their original rate of velocity, or that of the earth where they originally were, and consequently will commence to revolve. It would seem that if the cause mentioned be the source of motion they should not revolve if thrown apart east and west, or at right angles to a meridian. But if viewed in a different light it appears to be a fact that they would revolve in whatever direction separated. Suppose the halves of a sphere to be thus thrown apart and so retained; they have the momentum of the earth as before, but no *relative* motion, and consequently they are in the condition of the opposite points of rest of a vibrating pendulum, and will have an apparent revolution around the centre between them.

M. Baudrimont has observed that if torsion could be wholly avoided, a ball suspended or a horizontal bar would exhibit the rotation like a vibrating pendulum. But in these projects there is a fatal difficulty besides that from torsion. Such bodies, at the time when suspended, have the actual motion of objects at the place where they are, and will retain it; and consequently under no circumstances can they give results like those of the pendulum, or show any corresponding effect whatever.

In performing the pendulum experiment, the ball of the pendulum should be an accurately turned sphere or cylinder, having a place of suspension above and an elongated point below, well centered. It is best suspended by means of wire. The simplest mode to fasten it is to solder the wire into a hole drilled of the same size in a larger piece of metal, and secure this last in the ceiling or other support above. The swinging of the pendulum, by flexing the wire at the junction above, will after a while break it off. But if of steel instead of iron, the flexion will be distributed along a portion of its length, and the wire will last longer without breaking. To mark the motion, a circle (three feet or more in diameter) divided into degrees, is placed below the pendulum; the apparent motion of the plane of vibration, is observed (in north latitude) to be uniformly from left to right, or with the hands of a watch. For starting the pendulum when there is no better contrivance, it may be held, previous to letting it swing,

* Phil. Mag. [4] i. 561.

by a cord passed once around it, the hand resting at the same time on some firm object; when all oscillation has ceased, it may be let off by dropping the cord. In going the circuit, the ball of the pendulum has always the same side towards the north, and consequently it rotates on its axis with the earth.

However careful the trial, the motion of the pendulum soon appears to be somewhat elliptical. This has been attributed solely to accidental causes, and it is true that the slightest error of direction in letting off the pendulum will necessarily produce it. But on a following page, Rev. C. S. Lyman shows that a degree of ellipticity is a necessary result of the earth's rotation.

J. D. D.

Art. XXIII.—*Note on Heteronomic Isomorphism;* by James D. Dana.

In Volume Nine of this Journal* I published views on certain isomorphous groups among minerals, tracing this quality to a relation in atomic volume, a principle already admitted, but showing that this relation is most correctly exhibited when the aggregate atomic volume is divided by the number of atoms (or molecules) of the elements present. Thus for Fe O, I would divide the atomic volume, obtained in the usual way, by 2, which reduces the compound to the condition of a unit, as if consisting, as in effect it does, of $Fe^{\frac{1}{2}}$ $O^{\frac{1}{2}}$. Again, for Fe^2 O^3, I divided by 5, as the compound consists essentially of $Fe^{\frac{2}{5}}$ $O^{\frac{3}{5}}$, the sum of the fractions making a unit. This method carried out with the feldspars, exhibited a relation between them of actual (or approximate) equality in atomic volume, and also a connection between the system of crystallization of these species and the atomic volume,—the monometric (as Leucite) having the highest number, the monoclinic the next highest, and the triclinic a lower number.

Farther study is required before all the difficulties connected with this subject, arising from isomerism and differences in the elements, are mastered. But in the comparison of compounds consisting of like elements though in different proportions, the method appears to be satisfactory, and affords conclusions of great simplicity.

These views are well elucidated by many groups of silicates, and they give increased interest to the recent results of Rammelsberg with the tourmalines. This distinguished chemist, after numerous analyses, makes out *five* chemical groups in

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* P. 220, 1850.

this species, and in accounting for their similarity of crystallization, deduces as follows their atomic volumes.—(Pogg. Ann., lxxxi, 31.)

	Formulas of Tourmaline.	Mean atom. vol.
I.	$\dot{R}^3(\ddot{S}i^2, \ddot{B}^2)+3\ddot{R}(\ddot{S}i, \ddot{B})$ - - -	1808
II.	$\dot{R}^3(\ddot{S}i^2, \ddot{B}^2)+4\ddot{R}(\ddot{S}i, \ddot{B})$ - - -	2217
III.	$\dot{R}^3(\ddot{S}i^2, \ddot{B}^2)+6\ddot{R}(\ddot{S}i, \ddot{B})$ - - -	3013
IV.	$\dot{R}(\ddot{S}i, \ddot{B})+3\ddot{R}(\ddot{S}i, \ddot{B})$ - - -	1464
V.	$\dot{R}(\ddot{S}i, \ddot{B})+4\ddot{R}(\ddot{S}i, \ddot{B})$ - - -	1850

He then observes that the numbers 1464, 1808, 1850, 2217, 3013, have the relation (correcting his 1·25, by substituting 1·26)

$$1 : 1{\cdot}24 : 1{\cdot}26 : 1{\cdot}51 : 2{\cdot}06,$$

or very closely

$$1 : 1\tfrac{1}{4} : 1\tfrac{1}{2} : 2 = 4 : 5 : 6 : 8.$$

But let us now divide these numbers by the number of atoms of the elements, and we shall find the atomic volumes, as thus deduced, very closely equal.

		No. of atoms.	Atomic vol. ÷ No. of atoms.		Atomic vol. deduced.
Formula	I.	41*	1808 ÷ 41	=	44·1
"	II.	50	2217 ÷ 50	=	44·34
"	III.	68	3013 ÷ 68	=	44·31
"	IV.	33	1464 ÷ 33	=	44·36
"	V.	52	1850 ÷ 42	=	44·05

This equality is certainly very remarkable, and the identity of crystallization is attributed to it with good reason.

We also remark that the number of atoms 33, 41, 42, 50, 68, have to one another the ratios

$$1 : 1{\cdot}24 : 1{\cdot}27 : 1{\cdot}51 : 2{\cdot}06,$$

which are coincident, as will be observed, with the ratios obtained by Rammelsberg for the atomic volumes. *The ratios* 4 : 5 : 6 : 8, which this chemist deduces, *are in fact therefore only the ratios of the number of atoms*, 33 : 41 : 50 : 68.

Art. XXIV.—*Mineralogical Notices.* No. III.

1. *New Species.*

Gurolite, a new mineral; T. Anderson, (Phil. Mag. [4], i, 111.)—Occurs on Skye, at Storr, nine miles from Portree, in basalt; it is associated with apophyllite, stilbite and laumonite, though found in the finest specimens where these minerals do not abound. The name *gurolite* (more correctly *gyrolite*,) alludes to the spherical

* In the first formula, $\dot{R}^3$ contains 6 atoms or molecules; $\ddot{S}i^2$, 8; $3\ddot{R}$, 15; $3\ddot{S}i$ 12; making in all 41.

form of its concretions, and is from γυρος, *orbiculatus*. Structure radiating, and surface of the concretions appearing striated owing to the plates of which it is formed rising to irregular distances above the surface; cleaves easily parallel to the plates. Color white; lustre vitreous, passing into pearly on exposure; perfectly transparent in thin plates. Very tough. Hardness between 3 and 4. B.B. yields water, swells up and separates into thin pearly or silvery plates. On charcoal swells up, splitting into thin lamnæ and fuses to an opake enamel. With borax, yields a transparent colorless glass; with soda fuses with difficulty to an opake mass. Readily attacked by hydrochloric acid.

Composition according to T. Anderson,

	S̈i	Ä̇l	Ċa	Ṁg	Ḣ
	50·70	1·48	33·24	0·18	14·18=99·78
Oxygen	26·86		9·49		12·60

He thence deduces the oxygen ratio for the lime, silica and water, (considering the other ingredients as unessential,) 1 : 3 : 1½, and the formula 2ĊaS̈i+3Ḣ. The formula requires a little less lime and more silica and water, which discrepancy Mr. Anderson attributes to partial efflorescence. The ratio of lime and silica is the same as in Edelforsite. Its efflorescence and crystallization in plates distinguish it from dysclasite.

Aræoxene, a new vanadate of Lead and Zinc.—Kobell received this new mineral through Prof. Döbner. It was found at Dahn in the Palatinate, with galena, and had been considered a chromate of lead. It occurs massive but imperfectly crystalline, with some traces of a columnar structure. Color red, darker than crocoisite, with a brownish tinge; streak pale yellowish. H.=3. B.B. on coal fuses easily with intumescence, and yields an arsenical odor with a globule of lead, the latter being larger with soda. With borax fuses in the reduction flame to a bright green glass, which in the oxydation flame becomes gradually light olive green, then clear yellow, and on cooling changes to a pale greenish tint. Heated with concentrated muriatic acid, the powder easily decomposes, and the liquid is first yellow, then brownish, and after giving out chlorine, emerald green. On adding spirits of wine, heating it, and pouring off from the solution the separated chlorid of lead, it is still green; but on concentrating it by means of a vapor bath and then diluting it with water it takes a fine sky-blue color. In this characteristic, it is like other allied vanadium compounds. Von Kobell found in the mineral 48·7 p. c. of oxyd of lead and 16·32 of oxyd of zinc. The vanadium lead ore analyzed by Damour contained only 6·34 p. c. of oxyd of zinc. —(J. f. pr. Chem., l, 496.)

Enargite, a new ore of Copper; A. Breithaupt, (Poggend. Ann., lxxx, 383.)—Enargite comes from Morococha, district of

Jauli, in the Cordilleras of Peru, at a height of 14,000 feet (French), and also from a mine near Freiberg, along with other copper ores. It occurs in Peru abundantly in large masses containing occasional small druzes of crystals, imbedded with tennantite in crystalline limestone. The Freiberg mine affords it in acicular crystals, which are distinguished from other glances by the prismatic cleavage. Lustre metallic, slightly imperfect; color iron-black; streak black; H. = 3 or that of calc spar; G. = 4·43–4·445; easily pulverized. Crystallization trimetric; the crystals presenting the planes of a rhombic and rectangular prism; rhombic prism (∞P) = 98° 11′: cleavage prismatic, perfect; brachydiagonal and macrodiagonal distinct; basal indistinct; octahedral (P) in traces. Fracture uneven. B.B. in a glass tube, decrepitates and gives with little heat a sublimate of sulphur; in a stronger heat, fuses and produces sulphuret of arsenic of a reddish yellow color; on charcoal it gives out arsenous acid, oxyd of antimony and oxyd of zinc; and in the reduction flame, it finally yields with borax a globule of copper. Analysis of the Peruvian ore afforded Plattner, (ibid, p. 386)—

S	As	Sb	Cu	Fe	Zn	Ag
32·222	17·599	1·613	47·205	0·565	0·228	0·017=99·449

This gives the ratio for the sulphur,—the arsenic and antimony,—and the copper, iron and zinc, 1605 : 197 : 1214, or very nearly 8 : 1 : 6, whence he deduces the formula (writing Cu for copper and the allied metals)—

$$[8CuS + AsS^3] + [2CuS + AsS^3],$$

or perhaps $3(Cu, Fe, Zn)S + (As, Sb)S^5$,

equivalent to sulphur 32·64, arsenic 19·11, copper 48·25.

Carmine Spar; F. Sandberger, (Pogg. Ann. lxxx, 391.)—Carmine spar is a red mineral occurring with cube ore (Beudantite) at Horhausen in Saxony, in quartz and brown iron ore.

Crystallization not distinct, probably rhombic; occurs in clusters of fine needles and spheroidal forms of a columnar structure; cleavage parallel to the faces of a rhombic prism. Lustre vitreous, but pearly on a cleavage face; color carmine to tile-red; powder reddish-yellow; translucent; brittle; hardness 2·5, or between rock salt and calc spar. B.B. on charcoal fuses easily to a steel gray globule, giving out arsenical vapors. With soda, yields a globule of lead, and with borax the reaction of iron is obtained. In a glass tube over a spirit lamp, does not change. Heated in concentrated muriatic acid it dissolves very easily to a gold-yellow fluid, in which chlorid of gold does not deposit metallic gold; soluble in nitric acid. From these and other trials, it is inferred that the mineral is an anhydrous arsenate of oxyd of lead and iron; the quantitative relations have not been determined.

Dechenite, a vanadate of Lead; Dr. C. BERGEMANN, (Pogg. Ann. lxxx, 393.)—Dechenite comes from the Lauter valley in Rhenish Bavaria, near Nieder-Schlettenbach, where the rock is the "bunter sandstein." It occurs in small botryoidal masses, having a crystalline texture, and presenting when purest a dull red color. There appear to be indications of a rhombohedral cleavage. In these masses there are occasional wart-shaped grains of a more yellow color. The streak is always yellowish. Lustre of fresh fracture greasy; G.=5·81; H.=4, or that of green lead ore. B.B. alone in the platinum forceps it fuses easily to a yellowish glass; in a glass tube gives no water; on charcoal, does not decrepitate like the known vanadate ore, but fuses easily to a yellowish green pearl, which yields a slag containing some grains of lead. With more of the assay, the odor of arsenic is sometimes given off. With salt of phosphorus and borax, gives the reaction of vanadic acid. Soda yields a white enamel containing grains of lead.

According to the examinations, the mineral consists of

	$\dot{Pb}$	$\dddot{V}$		
1. Dull red variety,	47·164	52·915	=	100·079
2. " "	46·101	53·717	=	99·818
3. Yellowish "	49·27	50·57	=	99·84

The first two analyses afford the oxygen ratio for the base and acids 1:3, equivalent to the formula $\dot{Pb}\,\dddot{V}$ = vanadic acid 45·33, lead 54·67.

Octahedral oxyd of Antimony.—M. H. DE SENARMONT describes (Ann. Ch. Phys. [3], xxxi, 504,) an oxyd of antimony of octahedral forms from Sensa, near the sources of Aïn-el-Bebbouch, (Province of Constantine.) At one locality, the oxyd is in masses often cavernous, composed of capillary filaments parallel or a little divergent, and pearly or adamantine in lustre; it is the prismatic species. But at another mine called *Mimine*, the same oxyd exists in saccharoid masses, granular or compact, having cavities covered with octahedral crystals that are sometimes more than a centimetre in diameter. Several admitted of measurement and proved to be the regular octahedron, the cleavage octahedral, but a little difficult. The composition is that of the pure oxyd, or oxygen 15·68, antimony 84·32. G.=5·22–5·3, while that of the prismatic oxyd is 5·56. Hardness less than that of calcite. Colorless; transparent; strongly refracting without regular action on polarized light. Specific gravity of the massive variety 5·23, and color mostly grayish; contains sometimes less than 1 per cent. of lead, and there may be 1 to 3 per cent. of gray clay. It is probable, from the existence of thermal waters in the soil below, that these crystals were formed in the humid way. Oxyd of antimony is then *dimorphous*. Arsenous acid presents

the same forms. Wöhler* observed prismatic crystals which were recognized as like those of oxyd of antimony by Mitscherlich; while octahedral crystals are readily obtained by sublimation or by solution. [*Senarmontite* is an appropriate name for this octahedral oxyd.]

Mineral species described by Prof. C. U. Shepard, (Proc. Amer. Assoc., 4th Meeting at New Haven, p. 311.)—1. *Dysyntribite.* Occurs in considerable masses in St. Lawrence county, New York, and has some resemblance in appearance to serpentine. It is found at Rossie, and at Natural Bridge in Diana, and is usually in connection with the specular iron of the region. It is massive, granular, tough, almost dull, with an even splintery fracture; color dark green, grayish or yellowish, sometimes mottled with red and black. H. = 3·5–4. G. = 2·76–2·81. B.B. in thin fragments fuses to a white porcelainous mass. In an open tube yields water. Contains according to Prof. Shepard—

	$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{H}$	$\dot{C}a, \dot{M}g$	
	47·68	41·50	5·48	4·83	*trace*	= 99·49
Oxygen	24·77	19·39	1·21	4·29		

whence he deduces the formula $16\ddot{A}l\ddot{S}i + \dot{F}e^3\ddot{S}i^4 + 9\dot{H}$.
[The dysyntribite is somewhat remarkable for its external resemblance to serpentine, while at the same time it is aluminous in composition. The specimens are very various in appearance, and look much more like a rock than a mineral species, (as might be inferred from the improbable formula given,) appearing to be a result, to some extent, of metamorphic action.]

2. *Rutherfordite*, (ibid, p. 312.)—Occurs in crystals and grains at the gold mines of Rutherford Co., North Carolina, along with rutile, brookite, zircon and monazite. Monoclinic; M : M = 93°. Cleavage, none. Fracture conchoidal; lustre of fracture shining and resinous; color yellowish brown; opake. H. = 6·5; G. = 5·58–5·69. B.B. in a glass tube cracks, glows as if on fire, emits much moisture and turns yellow; alone infusible; with borax forms slowly a clear yellow glass.

According to trials by Prof. Shepard, it is supposed to contain titanic acid, oxyd of cerium and possibly oxyd of uranium and yttria.

3. *Paracolumbite*, (ibid, p. 313.)—Occurs a mile southwest of Taunton, Mass., in minute quantities in a boulder of granite containing a peculiar greenish-white feldspar. Massive, in grains and short irregular seams; iron-black, sometimes with a tinge of purple, and a black streak; imperfectly metallic; opake. H. about 5. From his examinations, Prof. Shepard infers that the mineral seems to be composed of the oxyds of iron and uranium in combination with a metallic acid, which is not the titanic.

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* Wöhler on the dimorphism of arsenous acid, Pogg. Ann., xxvi, 177.

4. *Houghite*, (ibid, p. 314.)—Occurs near Oxbow, St. Lawrence Co., N. Y., and also in Rossie, associated with spinel, from which region specimens were received by Prof. Shepard from Dr. Franklin B. Hough of Somerville. It presents oblong flattened reniform concretions, rarely above $\frac{3}{4}$ths of an inch long, with botryoidal surfaces, whitish externally and bluish or reddish white within; lustre faintly pearly, glimmering. Sometimes has a spinel crystal as a nucleus. H.=2·5. G.=2·02–2·03. It decrepitates and emits water before the blowpipe, losing $33\frac{1}{3}$ p. c. by ignition. Appears to be a hydrate of alumina and magnesia.

[Houghite has been studied recently by Mr. S. W. Johnson, of the Yale Analytical Laboratory, who finds that it is a pseudomorph, often of spinel and probably also at times of scapolite; some of his specimens are spinel crystals (octahedral) in one part, and true Houghite in another, and all conditions of change are well illustrated by them. Mr. Johnson is still engaged in his investigations on the subject.]

5. *Marasmolite*, (ibid, p. 315.)—From the feldspar quarry near Middletown, Ct., along with columbite, pitchblende and albite. Monometric, with cubic cleavage; color brownish black, and streak reddish brown; brittle; H.=3·5; G.=3·73–3·74. Composition, according to Prof. Shepard:—

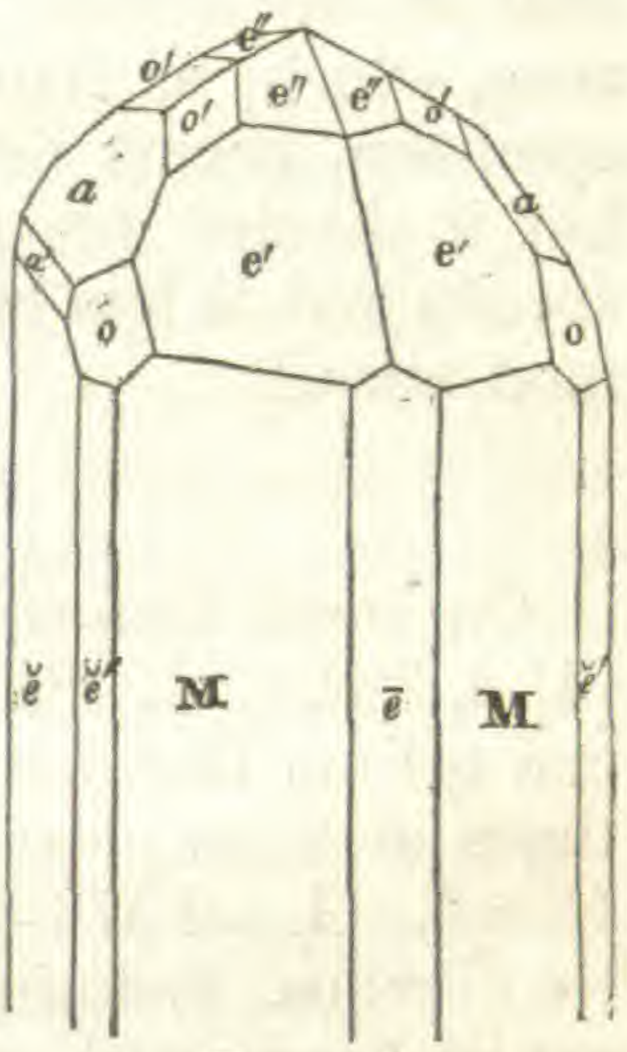
Sulphur 38·65 Zinc 49·19 Iron 12·16

affording the ratio 5 : 3 : 1, and the formula $3ZnS + FeS^2$. The name is from *μαρασμος*, *decaying*.—[The marasmolite, according to the writer's examinations of Prof. Shepard's specimen, is a brittle, partially decomposed blende, containing free sulphur in minute points throughout it, as seen with a glass. This free sulphur accounts for the excess in the analysis; allowing thus for a small excess, the composition will become $3ZnS+FeS$, which is the formula of the marmatite variety of blende.]

6. *Calyptolite*, (ibid, p. 316.)—From Haddam, with chrysoberyl, garnet and beryl; also from the feldspar quarry near Middletown. Crystals minute, and usually square prisms with pyramidal terminations; surfaces not smooth and often somewhat concave; color dark brown; lustre adamantine; opake. H.=6·5. G.=4·34. B.B. in an open tube, yields moisture, having an acid reaction, and becomes pale yellowish white; alone, whitens but does not fuse; does not fuse readily with soda; with borax dissolves slowly into a glass which is yellow while hot, but colorless on cooling. When heated in powder with sulphuric acid for some time, it appears to be completely decomposed, and the glass tube exhibits corrosion. "The quantity of the mineral was too small for a satisfactory examination; but the absence of silica, lime, magnesia and alumina was ascertained; and the probability that the substance is a fluo-columbate of some of the less com-

mon earths and oxyds, established." [We may mention that the most common form closely resembles that of garnet, and the mineral had been referred to this species, which it externally resembles. The angle of the pyramid is given at 122° to 124°; but the surfaces are so irregular that the measurements are uncertain.]

7. *Eumanite*, (ibid, p. 317).—From Chesterfield, Mass., at the albite locality. Only a single minute crystal less than a grain in weight is known. Form trimetric; M : M = 123°. M : e′ = 136°; e′ : e′ = 151° 30′; e′ : e″ = 159° 30′; $\breve{e} : a = 127° 40'$; M : $\breve{e}$ = 118°—118° 30′; e′ : a = 127° 30′; $a : o$ = 144° 20′; $\breve{e} : o$ = 128° 20′; e′ : o = 156° 30′; surface M rather imperfect and not very lustrous; the other faces brilliant. Color blackish-brown, resembling certain crystals of tin ore. Translucent; color by transmitted light deep red, like almandine garnet. H. above 6.



Eumanite.

[The crystal of eumanite has closely the form of topaz, even to the general character and position of the planes on the summit, and is near figure 393 in Dufrenoy's Mineralogy; the angles also are nearly identical. Topaz gives M : M = 124° 19′; and if M on $\breve{e}$ in eumanite is 118°, it will give 124° for M : M in eumanite—M, M, it should be noted, are the least lustrous faces of the crystal; M : e′ = 135° 59′ (136° in eumanite.) The mineral must therefore be closely isomorphous with topaz, if not identical with it, and some other characters are needed to show that the latter supposition is not true, although so peculiar in its color. In the figure, the edge o' : e″ on the right is parallel to the edge e″ : e″, but not so that on the left; we cannot say which is right.]

8. *Corundophilite*, (ibid, p. 318).—Occurs with corundum near Asheville in Buncombe county, N. Carolina, in imperfectly stellate groups, and also spreading out in laminæ between layers of corundum. A single crystal, exceedingly minute and less than $\frac{1}{5}$th of a grain in weight, was monoclinic and gave the angles M : M about 120°; P : M = 97° 30′ and 82° 30′; P($0P$) : $\infty P' \infty$ = 88° to 89°; P($0P$) : $mP'\infty$ = 122° 30′. Cleavage basal, perfect; also in traces parallel with M and the shorter diagonal of P. Lustre of cleavage faces commonly pearly. Color dark leek-green, passing into gray and greenish black; streak like the color. Thin laminæ flexible, but less so than talc. B.B. affords a little moisture in a glass tube; alone instantly turns black, and without phosphorescence. Melts at the extremity to a shining black globule; with borax, forms readily with effervescence a clear bottle green

glass. On analysis it afforded Prof. Shepard, Silica 34·75, protoxyd of iron 31·25, alumina 8·55, water 5·47, making a loss of nearly 20 p. c., a portion of which he attributes to the alkalies. 0·146 grámme was used in the analysis. Neither lime nor magnesia were detected. The name is from Corundum and φιλος, *friend.*

[This mineral, as observed by the writer, is usually thin foliated or micaceous. It closely resembles chloritoid in appearance, which, as stated by J. Lawrence Smith, who analyzed a specimen, occurs frequently with the Corundum of Asia Minor; but it divides into much thinner laminæ than is usual in that species and is less brittle. The angles are nearly those of common mica.]

2. *Described Species.*

On some Canadian Minerals, by T. S. Hunt, (Phil. Mag., [4], i, 322.) 1. *Perthite*, of Thomson.—This feldspathic mineral is from Bathurst, and forms part of a eurite rock, being sometimes in large cleavable masses. Form apparently monoclinic. H.=6. G.=2·576–2·579; a darker colored fragment 2·583. Lustre vitreous, inclining to pearly; color a light flesh red, in alternating bands, with reddish or pinchbeck brown, the bands half a line or a line wide, coincident with one of the planes T; the darker bands on the cleavage surface T give a golden reflexion when viewed perpendicularly, like aventurine feldspar. Analysis by Mr. Hunt.

$\ddot{S}i$	$\ddot{A}l$	$\ddot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{K}$	$\dot{N}a$		
66·44	18·35	1·00	0·67	0·24	6·37	5·56	ign.	·40=99·03
66·50	19·25		0·56	0·24	6·18	5·56	"	·44=98·73

The composition is that of orthoclase, to which species, as he observes, the mineral had been referred by Shepard, Dana and himself.

2. *Peristerite*, Thomson.—The specimens furnished Mr. Hunt by Dr. Wilson, as duplicates of those sent to Dr. Thomson, were a feldspar containing disseminated quartz grains; and others from the locality were fine cleavable masses often free from the quartz. Form triclinic, near albite in cleavage, being perfect parallel to P and M, less distinct with T, a fine play of colors on P, as in labradorite, a delicate cerulean blue prevailing which occasionally passes into light green and yellow. H.=6. G.=2·625–2·627. Composition according to Mr. Hunt:—

	$\ddot{S}i$	$\ddot{A}l$	$\ddot{F}e$	$\dot{N}a$	$\dot{K}$	$\dot{C}a$	$\dot{M}g$		
I.	66·80	21·80	0·30	7·00	0·58	2·52	0·20	ign.	0·60=99·80
II.	67·25					2·03		"	0·66

whence the mineral is *albite.*

3. *Bytownite.*—The specimen analyzed was from Dr. Holmes and was taken from a specimen pronounced by Dr. Thomson to

be this mineral. H. about 6·5. G.=2·732–2·733. Massive, granular, strongly coherent; grains with one perfect cleavage and indications of another oblique to it. Lustre vitreous, approaching to pearly upon the cleavage faces; translucent; color greenish white. The smoky blue mineral from Perth generally circulated among mineralogists as bytownite, is a mixture apparently of the true bytownite with what appears to be a black hornblende. Composition of the bytownite according to Mr. Hunt,

S̈i	Ä̇l	Ċa	Ṁg	Ḟe	Ṅa	K̇	Ḣ	
47·40	30·45	14·24	0·87	0·80	2·82	0·38	2·00	=98·96
47·30							1·80	

Mr. Hunt deduces from these results and the characteristics of the species, that it is anorthite. [The oxygen ratio for the protoxyds, peroxyds and silica is 1 : 2·66 : 4·62, which is wide from 1 : 3 : 4, the ratio for anorthite; and therefore, it must be, if this species, an impure variety of it. The mineral thiorsauite of Genth, has nearly the same composition according to Genth's analysis; but this Iceland feldspar is considered impure anorthite by Rammelsberg.]

4. *Labradorite.*—Common in boulders from Labrador to Canada West, but has not been observed in place. A specimen from Drummond, C. W., of a lavender blue color and pearl-gray opalescence, had the sp. gr. 2·697, and consisted as follows:—

S̈i	Ä̇l	Ċa	F̈e	Ṁg	Ṅa	K̇	Ḣ	
54·70	29·80	11·42	0·36	*trace*	2·44	0·33	0·40	=99·35

Mr. Hunt observes with regard to the water in this and other feldspars, that he agrees with Delesse and Laurent, in considering it as belonging to the constitution of the mineral and not hygroscopic.

5. *Raphilite* of Thomson.—This mineral from Lanarck, C. W., is tremolite. H.=5·5. G. (in powder) =2·845. Lustre vitreous silky; color grayish or greenish-white, becoming reddish on weathered surfaces. Composition:—

	S̈i	Ä̇l	Ċa	Ṁg	Ḟe	Ṁn	Ṅa	K̇		
	55·30	0·40	13·36	22·50	6·30	*traces*	0·80	0·25	ign. 0·30	=90·31
Oxygen	28·72	0·19	3·80	8·72	1·40		0·21	0·04		

6. *Retinalite and Serpentine.*—The retinalite of Thomson was founded on a serpentine from near Grenville, sent him by Dr. Holmes, and a portion of the same specimen he gave Mr. Hunt for analysis; other specimens were procured at the locality. It fills seams or penetrates granular limestone near a trap dyke. H.=3·5. G.=2·494–2·525–2·476. Lustre resinous; streak white; color honey yellow passing into oil green and olive green; translucent; fracture conchoidal. Composition:—

	S̈i	F̈e	Ṁg	Ṅa	Ḣ	
I.	39·34	1·80	43·02	*trace*	15·09	=99·25
II.	40·10	1·90	41·65	0·90	15·00	=99·55

Another serpentine of similar character, from Grand Calumet Island, having a pale wax color and sp. gr. 2·362–2·381, afforded—

S̈i	F̈e	Ṁg	Ḣ	
41·20	0·80	43·52	15·40	=100·92

Mr. Hunt observes that the mineral has the composition of marmolite of Hermann, but is not foliated; and he inclines to consider the species as not distinct from serpentine.

7. *Zircon.*—Crystals half an inch thick and an inch or more long occur at Grenville, along with tabular spar, calc spar, sphene, pyroxene and plumbago. G.=4·602–4·625. Color brownish red, passing into flesh-red and cherry-red. Analysis afforded Mr. Hunt:

Silica 33·7 Zirconia 67·3 =101·0

The zirconia contained a trace of iron which was not separated.

Celestine.—The crystallization of celestine has been studied with much labor by M. Hugard, and some new crystalline forms are described by him (Ann. des Mines, [4], xviii, 3.) Mr. Hugard adopts as the mean of his measurements, for M : M, 104°, the angle varying between 103° 30′ and 104° 30′; he observes that the crystals which vary most from this are chemically impure. A neat crystal from Lake Erie gave him constantly less than 104° (mean, 103° 30′); but the Lake Erie celestine contains a considerable proportion of sulphate of barytes. The paper is illustrated by twenty-seven figures.

Limestone of Predazzo.—This mineral, called Predazzite by Petzholdt, is a carbonate of lime and magnesia containing water. This chemist deduced the formula $2\dot{C}a\,\ddot{C}+\dot{M}g\,\ddot{C}\,\dot{H}$. J. Roth, by his analysis (J. f. pr. Chem. lii, 346,) makes the composition of a white variety, $2\,\dot{C}a\,\ddot{C}+\dot{M}g\,\dot{H}$ = carbonic acid 34·11, lime 43·41, magnesia 15·50, water 6·98=100. He obtained—

	C̈	Ċa	Ṁg	Ḣ		
I.	33·35	44·67	14·54	6·96	S̈i, Ä̇l, Ḟe 0·48	=100·00; G=1·868
II.	33·98	42·63	14·05	7·00	S̈i 0·29 Ä̇l, Ḟe 0·49	= 98·44; G=1·018

For another variety of a gray color he obtained, excluding the alumina, silica and oxyd of iron, which amount to 6 per cent.—

	C̈	Ċa	Ṁg	Ḣ	
I.	29·23	35·70	24·78	10·92	=100·63; G=1·005
II.	28·10	35·97	24·47	10·97	= 97·51; G=0·621

Whence he has the formula $\dot{C}a\,\ddot{C}+\dot{M}g\,\dot{H}$ = carbonic acid, 27·85, lime 35·44, magnesia 25·32, water 11·39=100. Brucite occurs in the marble of Predazzo, and also a variety of serpentine.

Composition of Apatite from Snarum; G. Rose (Monatsb. Akad. zu Berlin, March, 1851, 173.)—Analyses by M. Weber in the laboratory of H. Rose:—

	Ċa	F̈e, C̈e, Ẏ	P̈	Cl
I.	53·16	1·76	41·82	2·66
II.	53·79	1·74	41·47	"
III.	53·44	1·86	41·33	"
Mean,	53·46	1·79	41·54	2·66

Calculating the lime phosphate from the amount of phosphoric acid, the chlorid of calcium from the chlorine, and the fluorid from the remaining lime, G. Rose deduces for the composition—

$\dot{C}a^3\ddot{P}$	Ca Cl	Ca F	$\ddot{F}e\,\ddot{C}e\,\dot{Y}$
90·66	4·17	3·07	1·79

In the analysis formerly made by G. Rose, this chemist found in the Snarum apatite, lime 54·75 and chlorine 2·713, whence he deduced—

$\dot{C}a^3\ddot{P}$	Ca Cl	Ca Fl
91·13	4·28	4·59

agreeing very nearly with the analysis by Weber. Weber's results with the new modes of determination of phosphoric acid therefore confirm the earlier deductions of Rose.

Diaspore.—Occurs according to Prof. C. U. Shepard, (loc. cit. p. 319,) at the fluor spar and topaz vein at Trumbull, Conn., in thin or 6-sided tables, flattened parallel to the shorter diagonal. It is the species formerly announced by Prof. Shepard as euclase. M : M = 130° 30′, M : o = 125°; o : o = 152° 30′; o : on $\alpha\breve{P}\infty$ = 104° 30′. H. = 7–7·5. G. = 3·29. Analysis afforded Prof. Shepard, Alumina 84·9, water 15·1 = 100.

Hydrargillite from Brazil.—Von Kobell announces this mineral (J. f. pr. Chem. l, 493, 1850,) as occurring in Brazil, and as having been mistaken for wavellite. It occurs in spheroidal concretions, having a radiato-lamellar structure, giving some indications of rectangular prisms. Color grayish to yellowish-white; translucent; lustre pearly inclining to vitreous; hardness between calc spar and fluor spar. Dissolves wholly in concentrated sulphuric acid. Composition according to von Kobell:—alumina with a trace of silica 67·26, water 32·39 = 99·65, and giving the formula $\ddot{A}l\,\dot{H}^3$. It was found to contain no phosphoric acid.

New form of Compound Crystal of Quartz.—M. G. Rose has described a compound crystal of quartz (Monatsb. Akad. zu Berlin, March, 1851, p. 171), which consisted of four crystals, one a central, and each of the others united to the first correspondingly by a primary rhombohedral face, the axes of the central and the others, making an angle equal to the complement of double the angle between a rhombohedral plane in the primary and its vertical axis; the latter angle is 38° 13′ according to Kupffer, whence the inclination of the axes is 103° 34′. The primary faces of the pyramid are larger than those alternate, and the prism has its alternate planes larger so as to approach a 3-sided form. The specimen is from the serpentine of Reichenstein, and is associated with small crystals of arsenical iron.

Serpentine.—G. Rose has examined crystals of serpentine in the collections of Berlin (Monatsb. Berl. Akad.,) and sustains the

view that they are pseudomorphs of olivine. There are three crystals which have an interior of olivine. A portion of a crystal from Snarum, received from Quenstedt, afforded Hefter in his laboratory,—

	$\ddot{S}i$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	$\dot{H}$	
	41·93	53·18	2·02	0·25	4·00	=101·38–; G=3·0384
Oxygen	21·79	20·58	0·46	0·06	3·58	

Showing that it is a mixture of olivine and serpentine. The crystals of Snarum and of the Fassa valley in the Tyrol are therefore pseudomorphs. The villarsite of Dufrénoy, which is similar in its crystalline forms, he refers to the same origin. He regards serpentine as an amorphous material incapable of crystallization. Substances perhaps occur imperfectly crystallized, having the same composition; but the only substance of this nature, which he recognizes, is chrysotile. Schiller spar, which is allied in composition, the author regards as no natural mineral in crystallization, but a pseudomorph after augite, with which it is often associated. He alludes to the frequent occurrence of serpentine pseudomorphs imitative of many of the mineral species, as hornblende, augite, garnet, chondrodite, spinel, mica, &c.

Serpentine of the Vosges.—The serpentine of the Vosges and its associated minerals, have been investigated chemically and otherwise by M. Delesse (Ann. d. Mines, [4], xviii, 309), whose descriptions are very full and complete. The minerals noticed are garnet, chromic and magnetic iron, iron pyrites, diallage, chlorite, chrysotile, calcite, dolomite, nemalite, brucite, feldspar, quartz, talc, asbestus, and specular iron.

Garnet occurs of red, brownish and greenish or grayish-green colors. B.B. it fuses with difficulty, and in a tube yields some water. H.=6·5. G.=3·150. Composition:—

$\ddot{S}i$	$\ddot{A}l$	$\ddot{C}r$	$\ddot{F}e$	$\ddot{M}n$	$\dot{M}g$	$\dot{C}a$	
41·56	19·84	0·35	10·17	*trace*	22	4·25,	ign. 1·58=99·75

Diallage is sometimes disseminated through the serpentine, but occurs commonly in small masses or in the intersecting veins. Color deep olive-green, and occasionally, emerald green. The latter variety is sometimes found within a nodule of garnet. Lustre a little pearly but not like bronze. G=3·154. Analysis gave—

$\ddot{S}i$	$\ddot{C}r, \ddot{M}n$	$\dot{F}e$	$\dot{M}g$ (by diff.)	$\dot{C}a$		
56·33	1·50	6·73	31·93	1·40,	ign.	2·11=100

The 2·11 p. c. given off by heating are nearly all water. Formula $\dot{R}^3\ddot{S}i$.

Chlorite occurs in veins or in nodules of garnet, and evidently the garnet has been altered to chlorite, as the different stages of the process may be detected. B.B. becomes grayish and takes a metallic lustre, and if in lamellæ the edges are rounded, forming

a grayish green glass. With salt of phosphorus gives evidence of chrome, and with soda, a manganese reaction. Composition of the chlorite of the Col de Pertuis—

S̈i	Ä̇l	C̈r	Ḟe	Ṁn	Ṁg (by diff.)	Ċa	
33·23	14·78	1·49	6·28	1·39	30·76	1·86, ign. 10·21	=100

Bischof has shown that a solution of bicarbonate of magnesia will transform, even when cold, silicate of lime recently prepared into carbonate of lime and silicate of magnesia; and with this fact, M. Delesse observes that the change of garnet into chlorite may be explained. The pseudomorphosis has taken place over a wide extent.

Chrysotile occurs in seams having a delicate fibrous texture; it is translucent, and the fibres separated are transparent; color oil-green, usually clear, sometimes olive-green; lustre silky. G.=2·223. B.B. yields water; on platinum wire, it gives a bright light and fuses with difficulty to a glass slightly brownish. Dissolves with borax or soda. Composition:—

S̈i	Ä̇l	Ḟe	Ṁg (by diff.)	Ḣ	
41·58	0·42	1·69	42·61	13·70	=100

The picrolite of Stromeyer has the same composition.

Nemalite occurs at Xettes in the Vosges, and also at Saint Sabine. *Brucite* is found at Goujot.

The *Serpentine* is of various qualities and colors. Analyses:

	S̈i	Ä̇l	C̈r	Ḟe	Ṁn	Ċa	Ṁg (by diff.)	ign.
1. Blackish-green, Liésey,	40·83	0·92	0·68	7·39	*trace*	1·50	37·98	10·70=100
2. Maroon-red, Goujot,	42·26	1·51	—	7·11	——	0·80	38·90	9·42=100

Specific gravity of the first 2·749.

In the second analysis, the alumina as obtained included some chrome and oxyd of manganese. The serpentine of Goujot takes a fine polish and sells at 54 francs the square meter.

The author next discusses the relative age and the origin of the minerals and serpentine, giving many views of interest. He observes that of the minerals which have been formed in serpentine, those most magnetic (as those rich in iron) have remained in the paste, while those that are diamagnetic have been separated into fissures, so as to form veins or amygdaloids. The magnetic and diamagnetic forces, according to this view, have acted an important part in the development and distribution of the included minerals.

Picrolite of Silesia.—Analysis by Dr. List, (Ann. d. Ch. u. Pharm., lxxiv, 241):—

S̈i	Ṁg	Ḟe	Ḣ	
44·606	39·748	2·631	2·576	=99·561

Leuchtenbergite.—Breithaupt (Pogg. Ann., lxxx, 577) observes that the specimens of Leuchtenbergite are evidently more or less altered by exposure or otherwise, and this is farther proved by the fact that Komonen obtained but 8·62 per cent. of water,

and Hermann 12·5 per cent. He therefore suggests that quite probably the mineral may exist in the unaltered state and prove to be a distinct species.

Delessite of Naumann, is a ferruginous chlorite from amygdaloid.

Ozarkite.—On an examination of this mineral, Prof. Shepard obtained the following result (Proc. Assoc., loc. cit., p. 322.)—S̈i 40·91, Ä̈l 15·75, phos. lime 4·17, lime 4·52, water 15·10, and observes that this removes the mineral from Scolecite, to which it is referred by Mr. J. D. Whitney. [The investigations of the species by Messrs. Brush, Whitney and Shepard, the latter in two different trials, are so widely different, that we have not reason to believe that in any case a *simple* mineral has been examined.]

Soda-mesotype of the Zircon-syenite of Laurvig.—Analysis by C. G. Gmelin (Pogg. Ann., lxxxi, 311):—

S̈i	Ä̈l	Ṅa	K̇	Ḣ
48·680	26·369	16·002	20·362	9·550 = 100·958; G. = 2·207

Hence the formula Ṅa S̈i + Ä̈l S̈i + 2Ḣ. It gelatinizes with muriatic acid, before and after heating. The feldspar of the rock contains much soda.

Hydrosilicates of Alumina.—The following are analyses by M. Salvetat:—I. of Halloysite from Saint Jean de Colle, near Thiviers (Dordogne,)—II. Halloysite of unknown locality,—III. of Smectite from Condé, near Houdan (Seine-et-Oise,)—IV. Lenzinite from La Vilate, near Chanteloube, (Ann. Ch. Phys. [3], xxxi, 102.)

	S̈i	S̈i gel.	Ä̈l	F̈e	Ċa	Ṁg	K̇	Ṅa	Ḣ
I. *H.* from St. J. de C.	45·55	1·04	22·60	1·05	1·66	0·30	0·04	0·06	26·20, q'tz 1·04 = 99·46
Oxygen	23·60		10·55	0·32	0·46	0·12	0·01	0·01	23·28
II. *H.*, loc.?	45·44	—	24·00	1·35	0·83	0·09	0·93		26·70 = 99·35
Oxygen	23·60		11·21	0·41					23·93
III. *Smectite*	43·00	1·50	32·50	Ḟe 1·20	1·02	0·30	0·40		21·70 = 101·62
Oxygen	22·34		15·18						19·08
IV. *Lenzinite*	36·36	0·20	36·00	F̈e 1·95	—	0·18	0·50		21·50, q'tz 1·64 = 100·13
Oxygen	18·89		16·82	0·61					19·02

Formulas, omitting the protoxyds which are probably impurities,

I. and II. R̈ S̈i^2 + 7Ḣ III. Ä̈l^2 S̈i^3 + 7½Ḣ IV. Ä̈l S̈i + 3Ḣ.

The Halloysite from near Thiviers is tender, soapy and mild to the touch, of paler rose color than that of Montmorillon. B.B. infusible, and at a red heat loses color. Does not form a paste with water. In contact with water it divides into small fragments, and gives out bubbles of air with an argillaceous odor. Boiling sulphuric acid attacks the mineral. The second Halloysite has similar characters. On account of the difficulty of distinguishing between hygroscopic water and that of combination,

the author acknowledges that some doubt exists with regard to this term in the formula. Dried at 100° C. in a moist air, the 7Ḣ (obtained after drying at 16° C.) are reduced to 4Ḣ; and at 100° C. in a dry air, to 3Ḣ.

The Smectite is greenish, not homogeneous in appearance, and affords a magma of two substances, one colorless and the other slightly greenish, but both of the same composition; and the mass encloses here and there crystals of gypsum. In a certain state of humidity it appears transparent and almost gelatinous. It adheres strongly to the tongue. Moistened with water it yields an argillaceous odor and acts like Halloysite, except that it makes a plastic paste. It contains $7\frac{1}{2}$Ḣ, when dried at 16° C., $5\frac{1}{2}$, if dried at 100° in a moist atmosphere, and $4\frac{1}{2}$ at 100° in a dry atmosphere.

The Lenzinite occurs in pegmatite (whence it is explored for pottery) in small thin beds, having a brownish color, soft enough to be impressed with the fingers, but not plastic. On drying, the color slightly changes. B.B. infusible. Partly dissolved in hot sulphuric acid, leaving a white insoluble residue. At 100° C., the mineral contains $2\frac{1}{2}$Ḣ.

Atheriastite.—J. F. L. Hausmann shows (Pogg. Ann., lxxxi, 567,) that this mineral which was formerly referred to Scapolite, but recently instituted as a species by Weibye, is an altered scapolite, as is suggested by the writer in this Journal, vol. x, p. 246.

Feldspar of Laurvig and Friederichsvärn.—Analysis by C. G. Gmelin, (Pogg. Ann., lxxxi, 313,)—

	S̈i	Ä̇l	K̇	Ṅa	Ċa	F̈e	
1. Laurvig,	65·90	19·46	6 55	6·14	0·28	0·44,	ign. 0·12= 98·89; G.=2·5872
2. Friederichsvärn,	65·19	19·99	7·03	7·08	0·48	0·63,	" 0·38=100·78; G.=2·590

The first is of a pale greenish gray color, the second sky-blue.

Epidote.—The objections which Rammelsberg brought against the investigations of Hermann on the constitution of Epidote, are replied to by Hermann in the Jour. f. pr. Chem., vol. liv, p. 250. Hermann had in a former memoir presented the conclusion that the species included several distinct chemical compounds. Rammelsberg, in reply, after a new determination of the proportion of protoxyd and peroxyd of iron, referred all the varieties which he examined under a single formula, and suggested that the others would conform to it. Hermann in his recent memoir offers reasons in favor of his former deductions.

Gadolinite, (Phil. Mag. [4], i, 350.)—Occurs in Ireland near Galway in a trap rock containing also epidote.

New American localities, reported by Prof. C. U. Shepard.—(loc. cit., p. 320.) 1. *Ores of Uranium at Middletown, Ct.* Pitchblende occurs at the feldspar or "china-stone" quarry in small crystals which are octahedrons with truncated edges and

angles. It is associated with uranochre and also traces of carbonate of uranium and the sulphate (Johannite).

2. *Ores of Bismuth at Haddam, Ct.*—Bismuthine was noticed by Prof. Shepard some time since as occurring sparingly at the Chrysoberyl locality of Haddam. Bismutite and Bismuth ochre are now reported by him (loc. cit., p. 320) as occurring at the same place, the former in thin coatings upon crystals of Bismuthine and the latter in a pulverulent form and usually yellow.

3. *Samarskite in Rutherford Co., N. C.*—In angular grains, some weighing a quarter of an ounce, from the washings of one or more gold mines. The form appears from some of the fragments to be near that of Columbite. Color velvet black; streak dark reddish-brown. Opake; H.=5·5; G.=5·69. When first heated in a glass tube, it decrepitates, flies to pieces, glows slightly after the manner of Gadolinite, but remains of a black color. [No analysis or chemical examination is given.]

4. *Thorite at Danbury, Ct.*—This mineral is from Danbury, where it occurs with the Danburite, sphene and augite. It is stated to be either thorite or a new species. It occurs in minute square prisms ($\frac{1}{20}$th inch long) with truncated edges and having a pyramid at summit. The lower part of the four pyramidal planes forms a separate set of planes inclined at an angle of 160° to the terminal set; but in the specimen, only one out of the four of the lower set is present and this is not very distinct. Angle of the terminal set (P), over summit, 98°; same on M ($\infty P\infty$) 120°. Cleavage imperfect. Lustre resinous; color black. H.= 5 – 6. Heated in an open tube yields much moisture having an alkaline reaction. B.B. becomes brownish-red but does not fuse, but when most heated has finally a semi-fused aspect. With borax gives a glass colored by iron. [The characters given are insufficient to prove that the mineral is Thorite, as Prof. Shepard observes. The angle 98° is near the same in rutile, zircon, xenotime; calculating from this angle, the angle given as 120° would be 117° 40′. If 120° is right, 98° should be 90°, and the form might be cubic.]

Chromic iron of Baltimore.—Analysis by A. Rivot, (Ann. Ch. Phys., Oct., 1850, [3] xxx, 202.)

Fe	Al	Cr	Ca	Si, Ti?	
30·04	1·96	63·37	2·02	2·21	= 99·60

The oxygen of the peroxyd of iron and alumina is together nearly half of that of the oxyd of chrome.

Misy from Rammelsberg near Goslar.—Dr. List describes this iron sulphate as follows. (Ann. Chem. u. Pharm., lxxiv, 239.) It occurs as an aggregate of small crystalline scales having a pearly lustre approaching vitreous, a dull sulphur-yellow color. These scales, under a lens, are seen to be rhombic tables with

the acute lateral edge truncated. It does not properly dissolve in pure water, but after a while is decomposed, the fluid becoming brownish red and having an acid reaction; in water with a little sulphuric acid it is not decomposed. Analysis gave,—

S̈	F̈e	Ż̇n	Ṁg	K̇	Ḣ	
42·922	30·066	2·491	2·812	0·318	21·391	=100.

In another trial Dr. List obtained 43·208 S̈ and 30·365 F̈e. The zinc, magnesia and potash are attributable to mixture with some sulphate of zinc, of magnesia, and of potash present as impurity. Excluding these, the result becomes—

	S̈	F̈e	Ḣ
	47·075	40·622	12·313
Oxygen	28·203	12·170	10·947

whence the ratio, nearly, 2·5 : 1 : 1, and the formula $\dot{F}e^2\ddot{S}^5+6\dot{H}$, which is that of Copiapite (H. Rose) excepting the water which is 18Ḣ in that species.

Manganese Ores of the Pyrenees.—For a paper on the position and origin of these ores by M. Gruner, see Ann. des Mines, [4,] xviii, 61. The author also discusses the origin of associated minerals and ores.

Glaucodot.—This mineral according to Breithaupt, (Pogg. Ann., lxxxi, 578,) occurs at Orawitza in the Bannat along with a pale yellow calc spar. It is thin columnar. M. Patera obtained, Sulphur 19·78, arsenic 43·63, cobalt 32·02, iron 4·56.

Copper Nickel of Ayer.—Analysis by Ebelmen, (Ann. des Mines, [4,] xi, 55.)

As	Sb	S	Ni	Co	Fe		
54·05	0·05	2·18	43·50	0·30	0·45	Gangue	0·20 = 100·75

White Blende of New Jersey, (Phil. Mag. [4], i, 23.)—The colorless Blende from Franklin, New Jersey, called "Cleiophane" by Mr. Nuttall, has been analyzed by T. H. Henry, with the following result:—Zinc 67·46, sulphur 32·22 = 99·68, corresponding to a very pure blende. Sp. gr. at 60°, 4·063. A trace of cadmium was found by means of Wollaston's test.

Troostite of New Jersey, (Proc. Amer. Assoc. at New Haven, 4th meeting, p. 146.)—An analysis of Troostite by Henry Wurtz, afforded

S̈i	Ż̇n	Ṁn	Ḟe	Ṁg	Ċa	
27·91	59·93	3·73	5·35	1·66	1·60	= 100·18,

giving the oxygen ratio for the protoxyds and silica 14·96 : 14·50, or very closely the formula $\dot{Z}n^3\ddot{S}i$.

Calamine and Electric Calamine.—A paper on the analysis of these ores by Emil Schmidt is to be found in the Jour. f. pr. Chem., li, 257.

Wulfenite or Molybdate of lead from the mine Azulaques, near Blanca in Zacatecas.—Analysis afforded Dr. C. Bergemann,

(Pogg. Ann., lxxx, 400,) M̈o 37·65, Ṗb 62·35 = 100·00. The crystals are of a light yellow color.

Mimetene of the Mine Azulaques in Zacatecas.—Dr. C. Bergemann obtained in an analysis (Pogg., lxxx, 401,)

Ṗb	Ä̈s	Cl
74·961	23·065	2·445 = 100·471,

giving the formula Pb Cl + 3Ṗb³ Ä̈s. This corresponds to Arsenic acid 23·065, oxyd of lead 66·948, chlorine 2·445, lead 7·140.

Gray Copper from the foot of the ridge Mouzaïa in Algiers.—Analysis by Ebelmen (Ann. des Mines, [4,] xi, 47):—

S	Sb	As	Cu	Fe	Zn
27·25	14·77	9·12	41·57	4·66	2·24 = 99·61.

Specific gravity 4·749; occurs in highly modified dodecahedral crystals.

Dioptase.—Dioptase (Smaragdo-chalcite) is announced by F. Sandberger (Pogg. Ann., lxxxii, 133,) as occurring in a sandstone containing Spirifers in the Duchy of Nassau, betwen Oberlahnstein and Braubach.

Sulphate and carbonate of Copper at Bristol, Ct.; Prof. C. U. Shepard, (Proc. Amer. Assoc., New Haven, p. 322.)—A dull verdigris green mineral containing carbonic acid occurs upon the vitreous copper ore of Bristol. Prof. Shepard observes that if when more fully examined it proves to be a definite chemical compound, as he now suspects, it will then be proper to bestow upon it a mineralogical name. J. D. D.

(*To be continued.*)

Art. XXV.—*Notice of the Report on the Geology and Topography of a portion of the Lake Superior Land District;** by J. W. Foster and J. D. Whitney.

The district embraced within the Report of Messrs. Foster and Whitney covers an area of 16,000 square miles, and nearly the whole of it is still an unbroken wilderness. The opening of the Michigan Copper mines has given it a peculiar economical interest, and, more than this, it has a high geological importance, hardly exceeded elsewhere, on account of the singular character of the mineral region, the structure and relations of the rocks in different parts, and the display of the phenomena of drift. The investigations in the same region, made by Dr. C. T. Jackson,

* Report on the Geology and Topography of a portion of the Lake Superior Land District, in the State of Michigan; by J. W. Foster and J. D. Whitney, United States Geologists. In two parts. Part 1, Copper Lands. 244 pp. 8vo, with 12 plates and several maps. Washington, 1850. 31st Congress, 1st Session. Ex. Doc. No. 69.

have been noticed at length in this Journal. Messrs. Foster and Whitney, in the volume just published, present the first part of their Report on the region. The work, although mainly devoted to those points in the geology of the district bearing on the mines, and including much of practical detail on mining, presents a clear and systematic view of its general structure as far as examined, and conclusions of important geological bearing. A second part is promised, which shall contain further details of a more purely scientific character, with an account of the fossils, by Mr. James Hall, who accompanied the party in the explorations of one season. The authors acknowledge the aid of Messrs. S. W. Hill and E. Desor, as first assistants, Mr. Wm. Schlatter as draftsman, and Mr. W. D. Whitney as botanist. Mr. Desor's attention was particularly directed to the drift, and the results of his observations add much to the interest of the survey. On some geological points, the authors conflict with the conclusions of Dr. Jackson; and it remains for future investigation to clear up all the doubt that may remain upon the disputed questions.

We propose to run through with the work, giving a brief review of some of the results arrived at, and principally by citation from the volume.

The Introduction presents a historical view of the explorations in the Copper region. After touching upon the accounts of the Indians, and of the Canadian and other explorers, and also the Journey of Mr. H. R. Schoolcraft in 1819, 1820, and mentioning that the conclusion arrived at by exploration thus far, had been that the copper deposits to be found would be too inaccessible to be profitably worked—the authors allude to the investigations of Dr. Douglass Houghton, State Geologist of Michigan, and observe that "in his annual report, presented to the legislature of Michigan, February 1, 1841, the great features of the country were sketched with a masterly hand, and the first definite information with regard to the occurrence of the deposites of native copper in the rocks was laid before the world." This geologist had just planned a system for a thorough survey of the whole region, and had entered upon the prosecution of it, when, in the midst of his labors, he suddenly died by drowning, in October, 1847. Since this period, the region has been explored by Dr. C. T. Jackson, as already stated, and by the authors of the present report.

The Lake Superior Land district is bounded on the north by Lake Superior, east by St. Mary's river, south by Lakes Huron and Michigan, and west by the Montreal and Menomonee rivers, being situated between 45° and 49° north latitude and 83° 45′ and 90° 33′ west longitude. A striking feature in the topography of the region is the parallelism of the northwest shore of Lake Superior, the south shore, west of Keweenaw Point, and the

narrow island of Isle Royal between, proving, as the authors state, that this part of the lake must be the course of a great synclinal valley, arising from two parallel axes of elevation on opposite sides of the lake. We might add farther, that this course is *at right angles* to the great range of lakes that extends from Erie and Michigan northwest to the Northern ocean, which range is parallel to the Rocky Mountains and the Northwest coast of America on one side, and to Hudson's Bay and the shores of Davis Straits on the other.*

We cite with regard to the mountains, from pages 34, 35.

"1. Two granite belts occur in the Northwest—one forming the axis between the waters of Lake Superior and Hudson's Bay; the other between Lake Superior on the north and Lake Michigan and the Mississippi river on the south. The outline of the Canada range is N. 60° E., though subject to minor irregularities. It forms the rim of the Canada shore for more than two-thirds of its extent. The summits of this range are generally rounded, and rarely elevated 1,500 feet above the lake.

On the southern shore, a belt of granite approaches the lake near Dead river, and thence stretches westward, sinking down into a somewhat broken plain southwest of Keweenaw bay. Its widest expansion is about thirty miles. This belt constitutes the Huron mountains, which in places attain an elevation of 1,200 feet above the lake. They do not range in continuous chains, but exist in groups, radiating from a common centre, presenting a series of knobs, rising one above another, until the summit-level is attained. Their outline is rounded or waving—their slope gradual. The scenery is tame and uninteresting. Hemmed in by these knobs, it is not unusual to find numerous lakes and meadows covered with grass, forming an agreeable feature in the landscape. These meadows appear at one time to have been lakes, which have been filled with the detritus brought down from the surrounding hills, or drained in consequence of the water having worn down the barriers which existed at their outlets. Towards the western extremity of the district, the granite reappears in low ridges, and crosses the Montreal within twelve miles of its mouth. There are subordinate patches of granite in other portions of the district, attaining no great elevation, which will be described in the detailed report.

The metamorphic belt folded around the granite is traversed by numerous detached ridges of hornblende and feldspar rocks, ranging in E. and W. direction, and rarely rising more than 200 feet above the surrounding country, and present a more rugged aspect than the granite. A quartz range starts from the lake

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* Origin of the Grand Outline Features of the Earth, by J. D. Dana, this Journal, [2,] iii, 382 and 389.

shore at the mouth of Carp river, and extends westwardly beyond Teal lake. Its outlines are sharp and well defined, its escarpments bold, with fragments of rock strewn along its base. The boundaries of this group are defined in the accompanying maps.

2. A trap range starts from the head of Keweenaw Point and runs west twenty miles; then, curving to the southwest, crosses Portage lake near its head, and the Ontonagon river twelve miles from its mouth, and is thence prolonged into Wisconsin. Its length is more than one hundred and fifty miles; its width, from one to twelve. Between Iron and Presqu'-Isle rivers, a spur shoots off in the form of a crescent, constituting the Porcupine mountains. Another spur branches off from the main chain on the south, and is prolonged nearly parallel with it for twenty miles. This belt is made up of parallel ranges, presenting step-like or scalar declivities on the side opposite the lake, while the other consists of gradual slopes. Mount Houghton, near the head of Keweenaw Point, rises up like a dome, to the height of eight hundred and eighty-four feet; the Bohemian mountain, near Lac la Belle, is little inferior in height. The valley of Eagle river, on the northwest, is bounded by abrupt, overhanging cliffs, some of which rise to a height of five hundred feet above the surrounding country.

In the vicinity of the forks of the Ontonagon, the cliffs are equally bold, and from their summits the eye has an almost unlimited range. To the west, the trap range is distinctly marked for many miles, and the west branch of that stream flows along its base. The highest and most imposing cliffs are north and east of Agogebic lake. Farther west, the ranges are less precipitous and more irregular, much of the country traversed by these rocks consisting of rolling table-lands.

The highest elevation attained by the Porcupine mountains is one thousand three hundred and eighty feet. A remarkable gorge occurs in township 51, ranges 42 and 43. This gorge lies about two miles south of the lake, and in that distance the ground rises about a thousand feet. Suddenly the traveller finds himself on the brink of a precipice five hundred feet deep, at the base of which lies a small lake, so sheltered and hemmed in by the surrounding mountains that the winds rarely ruffle its surface. Gloomy evergreens skirt its shores, whose long and pendent branches are so faithfully reflected on the surface that the eye can with difficulty determine where the water ends and the shore begins. From this lake flows the Carp river, and the beholder occasionally catches a glimpse of its waters as they wind through a narrow valley towards the great reservoir. To the west, and extending for five miles, he sees a perpendicular wall three hundred feet in height—occasionally broken through by a transverse gorge—at the base of which are numerous fragments, which

have tumbled from the cliffs above. Still further down is to be seen the rich foliage of the maple intermingled with the dark green of the fir and cedar, and still beyond succeeds a level plain, stretching out for twenty miles, and clothed with a dense growth of trees; while in the distance the Black river hills are seen, blue and indistinct, resting like a cloud upon the horizon.

That portion of the district occupied by the detrital rocks rarely rises three hundred feet above the lake. It is not unusual to see ridges of sand and clay forming considerable elevations. The Grand Sable is a remarkable accumulation of this character, rising to the height of three hundred and forty-five feet. Point Iroquois, at the outlet of the lake, is three hundred and fifty feet in height, and composed wholly of transported materials."

There is much information in the Report on the meteorology of the region, and changes of level in the lakes, which for the present we pass by. Under the head of the Geology of the Copper Region, the trappean and other igneous rocks come first under consideration, 1. the ranges of Keweenaw Point; 2. those between Portage Lake and the Montreal river, in which district the Porcupine mountains constitute the highest points; and 3. those of Isle Royale. In these districts, the rocks are compact trap, amygdaloid, porphyritic trap, trap-breccia, epidote trap, and compact quartz or jasper.* Epidote is an abundant mineral. It frequently accompanies the amygdaloid, and often fills the cavities with radiated crystallizations. It also replaces the hornblende of the trap, forming the epidote trap which is very various in character; the seams of quartz and calc spar containing copper are almost always accompanied by this mineral. On the United States location, the trap and epidote are seen in alternating bands, the cavities of the former being filled with epidote and quartz, and those of the latter with quartz and calc spar. The Jaspery rock forms the highest points of the Porcupine mountains. It is usually of a deep brick red color, sometimes banded like ribbon-jasper, and contains seams of quartz. A quartzose porphyry has a brick-red color and contains small crystals of white feldspar, not generally exceeding an eighth of an inch in length. "Almost invariably, fine rounded particles of vitreous quartz are found distributed through the Jaspery base. It forms an eruptive mass, and often includes fragments of the pre-existing igneous and sedimentary rocks."

Besides these there is a singular rock of a feldspathic base, of a light reddish color, through which irregular crystals of red feldspar and small rounded particles of quartz are discoverable, intermixed with a greenish mineral which appears to be epidote.

The Porcupine mountains afford some copper, but there are not indications enough to warrant mining enterprises.

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* See also the Report of Dr. C. T. Jackson, pages 659 to 662.

Isle Royale is the counterpart of Keweenaw Point; but although the Jesuits formed the most extravagant notions of its mineral wealth, nothing has lately been revealed to justify those expectations; at least, it is vastly inferior to Keweenaw Point or the vicinity of the Ontonagon as a mining region. Moreover the soil is scanty and the timber dwarfed and stunted.

"The shores are lined with dense but dwarfed forests of cedar and spruce, with their branches interlocking and wreathed with long and drooping festoons of moss. While the tops of the trees flourish luxuriantly, the lower branches die off and stand out as so many spikes, to oppose the progress of the explorer. So dense is the interwoven mass of foliage that the noonday sunlight hardly penetrates it. The air is stifled; and at every step the explorer starts up swarms of musquitoes, which, the very instant he pauses, assail him. Bad as this region is by nature, man has rendered it still worse. Fires have swept over large tracts, consuming the leaves and twigs and destroying the growth, while the heavy winds have prostrated the half-charred trunks, and piled them up so as to form almost impenetrable barriers.

As we ascend the ridges, the maple and birch replace the cedar and the spruce, and the physical obstructions become less formidable. These ridges occur at short intervals, and preserve a great degree of parallelism—bearing northwest and southeast; they are uniformly precipitous on the north, and gently sloping on the south. The valleys between are occupied by swamps, clothed with a dense growth of resinous trees, or with small lakes arranged in chains. The coast of the island is rock bound, and, like Iceland, intersected by numerous *fiords*, or narrow and deeply indented bays."

Trappean rocks form numerous ridges, seldom reaching 500 feet in height and running from N.E. to S.W. They are at times in regular columns; and also pass into amygdaloid and varioloid trap. In numerous places they form distinctly *a series of beds* which are conformable with the detrital rocks. The intercalations of sandstone and trap* are well seen at Chippewa Harbor, there being no less than five in less than a mile.

"These beds bear S.W. and N.E., and dip from 12° to 20° to the S.E., and respectively vary from a foot to eighty feet in thickness. When traced across the harbor a few rods only in extent, they are found to have been subjected to a powerful dislocation, extending in a N.W. and S.E. course, and amounting to 971 feet in a linear direction.

At and near the junctions of these different rocks, marked changes in their lithological characters are observed, which throw much light on their origin.

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* Many facts of this nature are mentioned in Dr. Jackson's Report, page 472.

The *upper* portions of the sheets of trap are highly vesicular, resembling pumice. Fragments of amygdaloid, sometimes rounded, at others angular, are found enclosed in the pumice-like trap, as though they had become detached and afterwards reunited to the mass, while in a molten state. Numerous short and irregular fissures, extending to no great depth, are observed on the upper surface of the trap, in which sandstone has been deposited. * * * Between the *sandstone above* and the *trap below*, it is extremely difficult to determine where the one begins and the other ends. Fragments of amygdaloid, angular or partly rounded, are included in the sandstone—more numerous near the base than at the top of the deposits. Where the sandstone is imposed *on* the trap, there is little evidence of its having been metamorphosed; but, on the other hand, where the trap rests *on* the sandstone, the line of junction is clear and well defined. The trap is less vesicular; and the upper portion of the sandstone belt, for the distance of three or four feet, is converted into a ribbon jasper, having a compact texture. These phenomena have been observed at numerous places both on Isle Royale and Keweenaw Point. The beds of sandstone are not shattered, nor does the igneous rock penetrate in the form of dikes or ramifying veins. All the phenomena indicate that the igneous rocks were not protruded in the form of dikes between the strata, but that they flowed like lava sheets over the pre-existing surface; and that the sand was deposited in the fissures and depressions of the igneous belt, in some cases, while the mass was in an incandescent state."

Similar alternations occur in the cliffs of the shores, consisting of different igneous rocks.

"At another point on the coast the following section was observed:

	Feet.	Inches.
Compact trap, breaking into cuboidal blocks,	15	0
Porphyritic trap, - - - - -	0	3
Compact trap, - - - - -	4	0
Porphyritic trap, - - - - -	0	2
Compact trap, - - - - -	1	6
Porphyritic trap, - - - - -	1	0
Compact trap, - - - - -	1	6
	23	5

These alternations exhibited well defined lines of junction, and preserved their parallelism along the face of the cliff, as far as exposed. The bearing and dip were the same as in the section before described. The lines of division pursued an undeviating course through the several bands.

A small vein was observed at one point cutting vertically through these bands, and the veinstone exhibited marked changes in its passage through the different belts.

At a point about half a mile to the west, numerous alternations of compact trap and amygdaloid were observed, having the same regularity in bedding and inclination.

We have observed this banded structure in the igneous rocks, at short intervals, from Blake's Point nearly to Washington Harbor, a distance of forty-five miles; and throughout the entire extent of the island they present a remarkable uniformity in bearing and inclination. They were, undoubtedly, deposited at first in horizontal sheets, and owe their present inclination to the same upheaval which uplifted the associated sedimentary rocks. We regard them as purely igneous products, and not as the result of metamorphism."

In the chapter on the stratified and sedimentary rocks, other examples of the alternations of the trappean and detrital beds are given. But before mentioning the facts, the characters of the sedimentary or stratified rocks should be stated. These are comprised under three divisions; 1, *Conglomerate*, not strictly a sedimentary rock, but a volcanic tuff; 2, the *Inferior sandstone*, an equivalent, according to the authors, of the Potsdam sandstone; 3, *Compact or lower magnesian limestone*, referred to the age of the calciferous sandstone, chazy limestone, bird's eye and Black river limestones of the New York geologists. The fragments of trappean rocks in the conglomerate are often 18 inches in diameter; they have a rough surface as if fresh broken, and are not properly worn.

"The conglomerate appears to have been formed too rapidly to suppose that the masses were detached and rounded by the action of waves and currents, and deposited with silt and sand on the floor of the ancient ocean; for, while the contemporaneous sandstone remote from the line of volcanic foci does not exceed three hundred or four hundred feet in thickness, the united thickness of the conglomerate bands in the vicinity of the trappean range on Keweenaw Point exceeds five thousand feet. As we recede for a few miles from the line of the volcanic fissure, these amygdaloid pebbles disappear, and are replaced by arenaceous and argillaceous particles. We are, therefore, disposed to adopt the theory, as to the origin of such masses, first suggested by von Buch:* 'When basaltic islands and trachytic rocks rise on fissures, friction of the elevated rock against the walls of the fissures causes the elevated rock to be enclosed by conglomerates composed of its own matter. The granules composing the sandstones of many formations have been separated rather by friction against the erupted volcanic rock than destroyed by the erosive force of a neighboring sea. The existence of these friction conglomerates, which are met with in enormous masses in both hemispheres,

* Geognost. Briefe, p. 75–82.

testifies the intensity of the force with which the erupted rocks have been propelled from the interior through the earth's crust. The detritus has suddenly been taken up by the waters, which have then deposited it in the strata which it still covers.'

The junction between the trap and conglomerate is well displayed in the vicinity of Copper Harbor. The rocks bear nearly due west, with a northerly dip of 35°. The trap on the upper surface resembles pumice, the vesicles frequently empty, but oftener filled with calc spar, agates, chlorite, &c. Other portions are wrinkled, as though arrested while flowing. The lower portion of the conglomerate does not exhibit a clear and well-defined line of demarcation, but encloses angular masses of amygdaloid, as though the materials had been thrown down while the trap was in a viscid state. This appearance was particularly noticed a few hundred yards above Porter's island, where the pebbles, for the distance of twenty feet perpendicular, are enclosed in a scoriaceous mass."

On Keweenaw Point, the conglomerate rises to a height of 650 feet, and expands to a thickness of 4000 feet. The culminating points in the range are back of Horseshoe harbor and Grand Marais. At the base of the Porcupine mountains, the conglomerate and associated sandstone have a great thickness and there are numerous intercalations with trap. Near Montreal river it is 2000 feet thick and the boulders are sometimes fully three feet in diameter; the rock consists mostly of porphyritic trappean rocks and hornblende cemented by a calcareous paste.

The conditions or circumstances attending the formation of these beds of trap and their alternations with fragmentary deposits are thus explained by the authors.

"We may suppose that at one time all of this district formed a part of the bed of the primeval ocean. Adopting the theory of a cooling globe, we may further suppose that the waters were in a heated condition, and differed essentially in chemical composition from those of the present oceans. The earth's crust was intersected by numerous, powerful fissures, and the communication between the exterior and interior was unobstructed. Volcanic phenomena were much more frequent, and exerted on a grander scale. Each volcanic paroxysm would give rise to powerful currents and agitations of the water, and their abrading action in detaching portions of the pre-existing rocks, and depositing them in beds and layers on the floor of the ocean, would operate with greater intensity than at the present time. We can trace the remains of one volcanic fissure extending from the head of Keweenaw Point, in a southwesterly direction, to the western limits of the district; and of another, in a parallel direction, from the head of Neepigon bay to the western limits of

Isle Royale. Along the lines of these fissures existed numerous volcanic vents, like those observed at this day in Peru, Guatemala, and Java, which were characterized by periods of activity and repose. From these vents were poured forth numerous sheets of trap, which flowed over the sands and clays then in the progress of accumulation. During the throes and convulsions of the mass, portions of rock would become detached, and rounded simply by the effects of attrition, and jets of melted matter be projected as volcanic bombs through the air or water, which, on cooling, would assume spheroidal forms; while other portions of the rock, in a state of minute mechanical division, would be ejected in the form of ashes and sand, which, mingling with the water, would be deposited, as the oscillations subsided, among the sands and pebbles at the bottom of the sea. During the whole of this period of volcanic activity, the sands which now form the base of the Silurian system were in the progress of accumulation, and became mingled with these igneous products. The level of the sea, as evidenced by the ripple-marks, was subject to repeated alterations: sometimes it rose so shoal that the marks of the rippling waves were impressed on the sands; at others, it sank to unfathomable depths.

In the process of consolidation, the rocks became traversed by numerous fissures, and the water, charged with lime, was forced in like jets of steam, filling them with materials different from the enclosing mass. In this way the pores in the conglomerate and the vesicles of the amygdaloid were filled.

Thus alternating bands of igneous and aqueous rocks were formed, until finally the great crystalline masses of greenstone were protruded through the fissures, not in a liquid, but in a plastic state, lifting up the bedded trap and conglomerate, and causing them to dip at high angles from the axis of elevation. As the volcanic action diminished in energy, the detrital rocks enclosed fewer igneous products; and, when it ceased altogether, sand and clay, derived from regions remote from the lines of disturbance, were the only materials which, for a time, were deposited on the floor of the ocean.

To illustrate the nature of volcanic action, we need only to revert to instances which have happened within the present century. So recently as 1831, a mass of rock rose up from the sea near the coast of Sicily, where soundings had previously been made to the depth of six hundred feet. This mass, which was subsequently known as Graham's island, rose gradually from the water, until it attained an elevation of two hundred feet above the surface, and a circumference of three miles. It slowly diminished to the circumference of three hundred yards, and in the course of three months sank eleven feet below the water, leaving a dangerous reef.

The formation of this island was attended with earthquakes and water-spouts, and the effusion of vast quantities of steam and vapor. The surrounding water was covered with scoriæ and the bodies of fishes. Fragments of rock were detached by the waves and currents, and deposited in the bottom of the sea.

Now, if its bed were laid bare, it would probably be found to exhibit a section somewhat like the following:

1. A mass of volcanic rock, forming an axis or cone, crystalline or granular in proportion to the rapidity or slowness with which it parted with its heat, and the degree of pressure to which it had been subjected.

2. Volcanic breccia, consisting of fragments which had become detached and afterwards reunited with the fluid mass.

3. Coarse conglomerate, composed for the most part of pebbles derived from the upheaved mass.

4. Beds of arenaceous and calcareous particles, brought down by the rivers of the adjacent coast, and enveloping the remains of fishes, if not too perishable in their nature, and of shells, inhabiting the surrounding sea.

The conglomerates and trap tuffs would rapidly thin out as we receded from the volcanic focus, and be replaced by the silts and sediments derived from the rivers flowing into the sea.

Such, we conceive, was the process by which the rocks embraced in this report were formed. The heated condition of the fluids, as well as the gaseous exhalations constantly escaping through the open fissures, would prevent the development of animal and vegetable life.

When the igneous action became dormant, the water, having parted with a portion of its heat, would absorb carbonic acid from the atmosphere, which, uniting with the lime held in solution, would be precipitated in beds and layers at the bottom of the sea. This Humboldt conjectures to have been the origin of the vast deposits forming the Silurian limestones. As the condition of the water changed, the numerous types of animal life sprang into being, whose remains are so profusely scattered throughout the strata of that era."

There can be no doubt, judging from the known effects of igneous action, that the authors are correct in representing the conglomerate as a result attendant upon the igneous ejections. The action of the waters of the ocean on a lava stream was exhibited on a grand scale at the eruption of Kilauea, (Hawaii) in 1840, where the fused rock on reaching the sea, 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," and as a result three conical elevations were thrown up in a few days, the smallest 150,

and the largest 250 feet in height. The same effects would take place in the depths of an ocean, only far more vast, when the opened fissures lie their whole length exposed to the waters; and the results would vary according to the condition or progress of the eruption, the currents that were in action at the time, and the character of the region around. Adding also the friction of the eruptive rock against the walls of the opened fissures, as suggested by von Buch, and we have a sufficient cause for the formation of the fragmentary beds.

That there were actual volcanoes in the Lake Superior region, may be doubted; for the same results as are there observed might take place by eruptions through fissures without the existence of a permanent vent and cone. In fact, nearly all (if not all) the ejections about modern volcanoes are through fissures in the slopes of the mountain and in the surrounding country. Farther evidence is needed on this point.

The *sandstone* of the region contains beds of the conglomerate and its layers alternate in many cases with the beds of trap, proving that all belong to one epoch. The rock varies in color from different dark brown shades to reddish or red; and also passes into a slate.

The *compact or lower magnesian* limestone contains fossils, which are shown by Mr. James Hall to correspond in age with the lower of the New York series. A conspicuous fossil is a Maclurea like a species from the Chazy limestone. The Leptænæ have the characters of *L. sericea*, which in its highest range does not extend above the Clinton group of New York. The species of *Orthis*, though too obscure to be identified, have the characters known only in those of the lower Silurian beds. A *Crinoid* (*Glyptocrinus*) is not more recent than the Hudson River group. The other fossils observed tend to the same conclusion.

The age of the conglomerate associated with the trap is the disputed point to which we have referred in the early part of this review. The resemblance of the trap ranges and the associated sandstones of Michigan to those of Connecticut and New Jersey had led geologists to refer all to the same era; and the age of the latter being shown by the occurrence of fossils, and especially the fossil fish, described by Mr. W. C. Redfield, to be subsequent to the coal, the era of the former was thereby supposed to be settled. Dr. Jackson, after his examinations still sustains this view. Messrs. Foster and Whitney state that the magnesian limestone, whose age is evidently lower Silurian, has been found by them to *overlie* the conglomerate, and hence they place the trap and conglomerate in the lowest Silurian or as an equiva-

lent of the Potsdam sandstone. The following are their observations on this point.—p. 117.

"The sandstone, as we ascend from the lower strata to the higher, is found to be less colored by the oxyds of iron, and to take into its composition particles of lime, until finally it passes into well characterized, compact, magnesian limestone. The upper portions of the sandstone effervesce with acids, where a granular structure only is recognizable by the eye. We apply the term magnesian to this belt to define its lithological characters, although the associated organic remains would seem to indicate the presence of several of the lower Silurian groups, which cannot be recognized by lithological differences.

The whole of the northern slope of the anticlinal axis bears evident marks of having been subjected to extensive denudation; and hence over the greater portion of this region we look in vain for traces of limestone rocks. If they existed, they have been swept away; and wherever we penetrate through the thick deposit of clay and sand, we find the rock in place to be sandstone. A limited patch of limestone, however, yet remains west of L'Anse, forming the highest elevation in that direction till we reach the trap range. It is in township 51, range 35, and occupies a portion of four sections. It was first discovered by Mr. C. C. Douglass, in the summer of 1846, but nothing farther was known until the township was subdivided in 1848, when its extent and exact locality were determined.

Near the quarter-post, between sections 13 and 14, township 51, range 35, the limestone is seen in place, forming a bluff, about 50 feet above a small stream at its base. Here the strata are nearly horizontal, though large blocks have slidden down the side of the hill, and thus appear to dip towards the east. The limestone rests upon a white sandstone, which belongs to the upper part of the formation which we have described as underlying the whole of this valley.

A little to the west of the line, between sections 23 and 24, and extending for a little more than a mile, the limestone is seen in a high cliff which runs south and gradually bends to the eastward, crossing the line, in several ridges, near the southern limit of these sections, when it disappears beneath the drift materials. Ledges of rock are occasionally exposed, from 20 to 50 feet in thickness. The height of the bluff above the surrounding country is fully 200 feet; and about 600 feet above Lake Superior. The limestone is distinctly stratified, in layers from an inch to a foot in thickness, which dip, according to measurements taken along the lower edge of the precipitous portion, from 25° to 30°; and the direction of the dip is always to the eastward, varying at different points from N. 50° E. to S. 20° E.

It is of a buff color—in some places silicious, with quartzose nodules; but in others, highly magnesian, containing about 45 per cent. of carbonate of magnesia.

From the horizontality of the first described deposit, which occurs about a quarter of a mile to the north, it seems evident that the limestone overlies the sandstone, although the position of the inclined beds of the more southerly portion of the limestone is at first difficult to explain, since the surrounding country is low and level, and underlaid by sandstone in horizontal beds. It seems evident that at this point the country has been disturbed and upheaved by igneous action beneath, which has raised the strata, without any appearance of trappean rocks on the surface. This view of the case is corroborated by the fact that at no great distance from this point an elevation occurs from which the strata of sandstone dip on all sides, and although there is no igneous rock visible, yet it is evident that the sandstone has been raised in a dome-like protuberance by a mass of igneous rock pressing upon it from below. The same cause is also indicated by the irregular variation of the magnetic needle in the vicinity observed by the linear surveyors, which is unusual except when caused by the proximity of the trappean rocks.

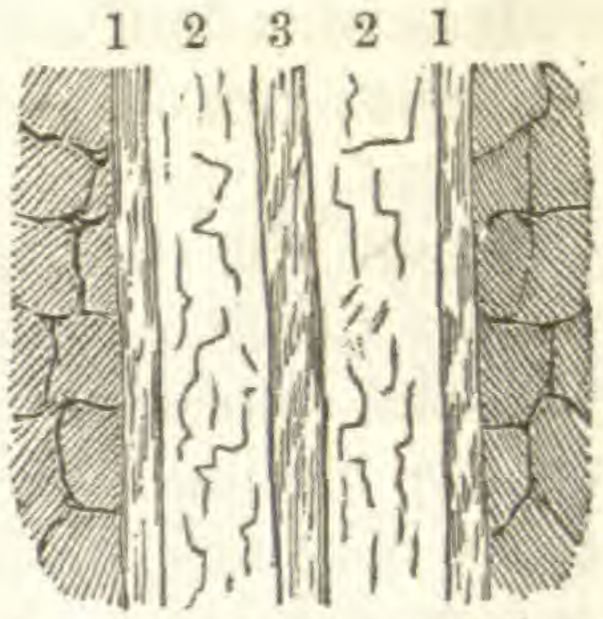
The isolated knob of trap called Silver mountain, which has been before described, is an example in point—where, however, the elevating force has not only been sufficient to raise and shatter the strata of sandstone, but, at the same time, to protrude a mass of molten igneous matter above the surface.

Geological Position.—As to the geological position of this limestone, there can be little doubt that it is superior to the sandstone. Mr. Whitney and Mr. Hill have both explored it with care, and both have arrived at the same conclusion. The sandstone, wherever observed in this region, rests unconformably on the argillaceous schists. It is seen in this position ten miles east of this deposit, and is found in the beds of the streams in this vicinity. On the southern side of the axis, Messrs. Foster and Hill found these two groups occupying the same relative position."

The point is one of great interest to American geology, and will not be permitted to rest until the facts are too clearly made out to admit of farther discussion.

In the chapters on Mines and Mining, much valuable information is condensed which will be found practically useful. The following paragraphs present some interesting facts respecting the metallic veins of the region.

"The materials composing the gangue of veins are often arranged in parallel plates, constituting what the Cornish miners call *comby* lodes. De la Beche supposes that this arrangement resulted from successive openings of the fissure.



The annexed is a section of the gangue of a vein on the southeast quarter of section 10, township 60, range 39, Isle Royale:

1. Laumonite, half an inch.

2. Prehnite, with native copper, two inches.

3. Clay, probably decomposed chlorite, one inch.

This vein appears to have been subjected to three successive openings.

The east vein of the Northwest Company exhibits two combs: that attached to the foot-wall, six inches in width, is composed of calc-spar with little copper; that attached to the hanging-wall, twelve inches in width, consists of chlorite, quartz, and calc-spar, investing copper in spangles and masses.

We have given sections of several veins in the chapter on mines, and they may be referred to in the further illustration of the structure of the veins of this region.

In the Cliff vein, there are two combs—that attached to the foot-wall containing most of the masses, while the other carries disseminated copper. The sheets of native copper, as a general thing, though not invariably, occupy the foot-wall of the vein.

Where crystals occur investing the walls, with their faces opposite, whether separated or interlocked, they afford strong presumptive evidence of the original width of the fissure.

The Prince vein, Canada shore, affords a beautiful illustration of this. The vein on Spar island is about fourteen feet in width, the walls being invested with amethystine quartz, with the faces turned outwards, occupying two feet in width, while the intermediate space is filled in for the most part with calc-spar and pyritous copper.

It is difficult to determine the order in which the materials composing the matrix of veins were deposited. In some cases the earthy substances were deposited before the metallic, and in others it is evident that copper existed in the fissures before the process of filling was complete. It is probable, however, that the copper was formed at different times.

At the Copper Falls mine, for example, we find small specks of copper enclosed in obtuse rhombohedral crystals of calc-spar, variously modified; again, we find native copper deposited *around* crystals of analcime and calc-spar, taking the form of the faces of the crystals, every line and wave being faithfully represented, as in the electrotype process. The copper often appears in arborescent forms, invested with calc-spar.

The Prince mine affords specimens of dog-tooth spar, studded with minute crystals of bi-sulphuret of copper, while the vitreous copper is often enclosed in a matrix of carbonate of lime.

The silver in this vein is found in thin leaves, between the laminæ or joints of the crystallized spar, indicating that it was deposited subsequent to the filling of the vein.

At the Minnesota mine it is not unusual to find spongiform copper adhering to the walls, which would seem to indicate that copper was the first substance deposited in the fissure. Again we find it deposited in thin plates between the joints of the crystallized quartz, which would indicate that the latter was deposited subsequent to the former. We have before us a specimen from this mine, consisting of native copper, native silver, crystallized quartz, and carbonate of lime, (calc-spar.) The copper and silver are distinct, and appear to be chemically pure. The form of the crystals of quartz is impressed on the silver and copper, and in the body of the crystals there is no trace of a metallic substance. The calc-spar, however, conforms to the silver and copper, both of these metals being disseminated through it. The silver occurs in imperfect octohedrons of the size of a pea.

This arrangement would seem to indicate the following order in the deposition of the materials: 1. Quartz; 2. Copper and silver; 3. Calc-spar.

At the Cliff and North American mines perfect crystals of copper occur only in the cavities of the matrix; when in contact with quartz, it takes the form of this substance.

The inference from these facts is, that some of the earthy materials constituting the veinstone were deposited prior to the copper and silver, while others were subsequent in their deposition.

The silver is generally found to occupy a certain position in the lode. Thus, at the Copper Falls mine, it is most abundant near the junction of the trap and conglomerate on the north; at the Cliff mine, near the junction of the crystalline greenstone and granular trap. Although silver is intimately associated with copper, yet it does not occur in sufficient quantity to justify the expense of separating the two metals. The lodes are frequently brecciated, the angular fragments evidently having been derived from the adjacent walls—and are most abundant above the points where the fissure is nearly closed."—pp. 172–174.

The authors adopt the electro-chemical theory in explaining the origin of the veins. The fact that the copper is found investing minerals, copying every wave and stria, and even incrusting zeolitic crystallizations which could not have stood the heat of fusion, favors this view of their origin.

This article has already exceeded our estimated limits and we omit therefore other citations marked off, and close with a few paragraphs on the *Cliff Mine*, pp. 127–130.

"The Cliff mine is situated on Keweenaw Point, about three miles from the lake shore, in the southwest quarter section 36, township 58 north, range 32 west. A range of elevated hills sweeps round in a crescent form, trending in a southwesterly direction, and forming the western boundary of the valley of Eagle river. In places these hills attain an elevation of 800 feet, and towards the valley present bold mural escarpments, while on the side exposed to the lake the slope is gradual. This range is composed of trappean rocks. The summit is capped by a hard crystalline greenstone, as at the Cliff mine, passing into a feldspathic porphyry, as at the Albion. Below, and forming the base of the ridge, is a belt of granular trap, occasionally amygdaloidal. Between the two, there is a thin belt of slaty chlorite about twelve feet in thickness. These belts dip to the north at an angle of 45°, conforming in this respect to the inclination of the detrital rocks which flank the range on the north. Wherever veins are observed in the greenstone, they are pinched and barren; but where they enter the compact or granular trap they expand in width, and become charged with metal. This trap has a good degree of firmness, and consists of labrador feldspar, and chlorite. It has been remarked that the best rock in this region for productive veins is neither a crystalline greenstone nor a soft porous amygdaloid, but a granular trap, with occasional amygdules scattered through it, and possessing a good degree of consistency. Where veins enter the greenstone, as before remarked, they become pinched; where they penetrate the soft amygdaloid, they become scattered and lose themselves.

The lode of the Cliff mine is seen to occupy a break or depression in the hill, and thence can be traced to its base. It was discovered in the summer of 1845, and during the succeeding fall a drift was carried into the greenstone about one hundred feet, and between that point and the summit several others were opened. When first discovered, the vein was only to be seen in the upper belt of greenstone, the metalliferous zone being concealed by detritus. No one could have inferred from its appearance at that time that the enormous masses of copper existed but a short distance below which subsequent explorations revealed. * * * * At the summit it appeared hardly more than an inch or two in width: the gangue was mostly prehnite, with copper associated with silver, incrusted with beautiful capillary crystals of red oxyd. Further down the vein was again exposed; here it had expanded to the width of nearly two feet, the veinstone consisting of a series of reticulations of laumonite.

Up to this period the sandstone and conglomerate were supposed by many to afford the best mining-ground, and that to this source they were to look for permanent supplies of the sulphurets of copper. During the winter of 1845–'46, some German miners, in clearing away the talus near the base of the cliff,

discovered a small loose specimen of mass copper. This stimulated them in their researches, which resulted in the discovery of the vein in the belt of granular trap about twelve feet to the east, showing that it had been subjected to that amount of heave or dislocation. * * * * From that time to the present day, hardly a month has elapsed without developing new masses; and their occurrence, so far from creating wonder, is regarded as a matter of course. The largest single mass hitherto exposed weighed about fifty tons. * * * * *

From the reports of the trustees rendered in 1849 and 1850 we gather the following information:

The amount of capital stock paid in by the stockholders is $110,000. The personal effects of the company on the first of December, 1848, were $140,982, leaving a surplus of $111,105 —a sum a little more than equivalent to the entire capital stock. This statement does not include the mine, with its fixtures and improvements, such as the stamping-mill, furnace, &c. * * * *

	Products.	Expenses.
1846 - -	$8,870,95	$32,203,44
1847 - -	70,977,32	61,737,85
1848 - -	166,407,02	67,667,58
1849 - -	244,237,54	106,968,77

This embraces such expenses only as were incurred at the mine; those of insurance, commissions, freights, &c., are excluded. The cost of transportation to Boston is $15 per ton; to Pittsburg, $7,50. The incidental expenses amount to about 20 per cent., in addition to those of mining.

The company have erected the necessary works at Pittsburg for smelting and refining the copper, and they estimate that the shipments for the year ending December, 1849, will amount to 660 tons of refined copper.

The product of silver for the year 1849 was $2,365,30."

ART. XXVI.—*Effects of Lightning during a storm on the first of July*, 1851, *at Attleboro', Mass.;* by Mr. HENRY RICE.

ON the 1st of July a thunder storm commenced in the S.W., at about $6\frac{3}{4}$ A.M., the wind being at the time in the south. At $7\frac{1}{2}$ A. M. the wind had changed into the S.W. At a little before 8 o'clock the shower seemed to divide, one part going to the north and the other to the south of this place. At 8 A. M. the wind had changed into the east, the clouds at the same time coming from the south. At $8\frac{1}{4}$ it commenced raining here, the shower which was at the south having come up and the wind having changed into the south. One flash of lightning which seemed to go directly downwards, was succeeded by the report in eight seconds, and the report continued audible for thirty seconds, hence

we may suppose the distance of this flash to have been about $1\frac{3}{4}$ miles; this I think was as near as any to this place.

At a distance of about four miles south of this place, the lightning struck the upper telegraph wire and passed off in both directions, giving reports as loud as that of "a pistol fired in a close room," in the telegraphic offices in Boston and Providence. The lightning split or splintered nearly all the posts for about one mile, and broke several of the glass insulators. The most southern post which was affected by the lightning is situated about four miles south of this place; calling that post 1, and numbering all the posts which have been affected, I find the last one split is No. 28. Nos. 9, 24 and 27 are not injured in any way. No. 18 is split the most of any; this post stands in a very wet place, in fact it is surrounded by water. Nearly every post that was affected had a long, narrow spiral groove dug out along its whole length, corresponding with the grain of the wood. Post No. 18 was split into three nearly equal pieces, the iron spikes torn out and the upper insulator broken. Persons living near the line of the telegraph say they saw the flash as it passed along on the wires; they also heard several slight reports similar to those of percussion caps.

As the shower passed on to the east, the lightning struck a house belonging to Mr. Ebenezer Draper, situated in the village of Attleboro', known as "Attleboro' City." This house was struck twice, the second discharge being about three minutes after the first. There was no lightning rod on the house, and the nearest one to the house was situated about fifty rods distant. There are, I believe, but three rods in the village, or within $\frac{1}{4}$ mile of the house. This house is a one-story frame building, standing upon a stratum of graywacke conglomerate soil of the red slaty variety, and has been built 50 or 60 years. The house fronts the road which runs through the village in a N.E. and S.W. direction. At each end and within four feet of the house stands a Balm of Gilead (Populus candicans). These trees are very much branched, but the branches of the tree at the N.E. end of the house do not extend over the house to any considerable extent. There were four persons in the house at the time it was struck, viz., Mr. Ebenezer Draper and wife and daughter, and Mr. Daniel Barney.

1.

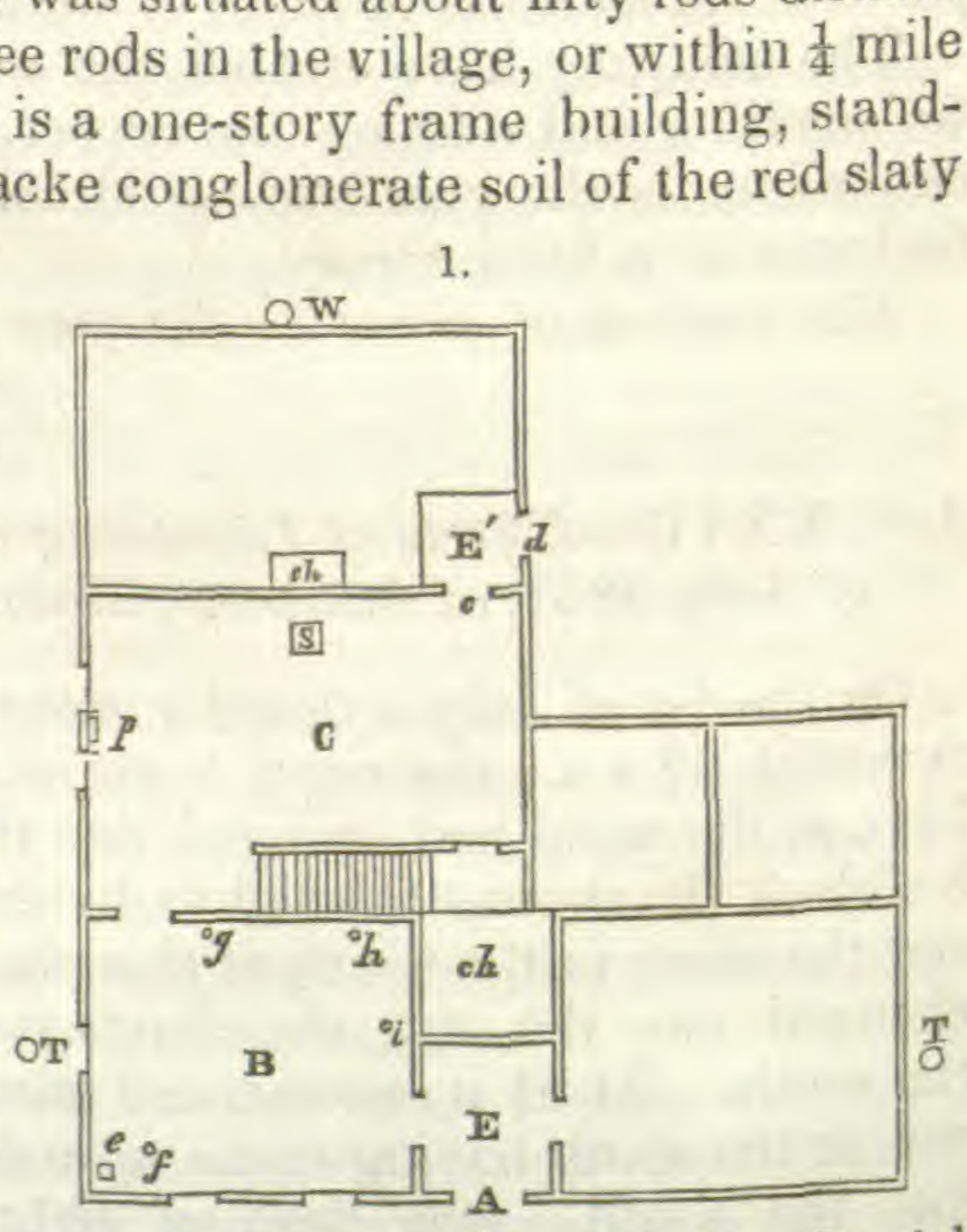
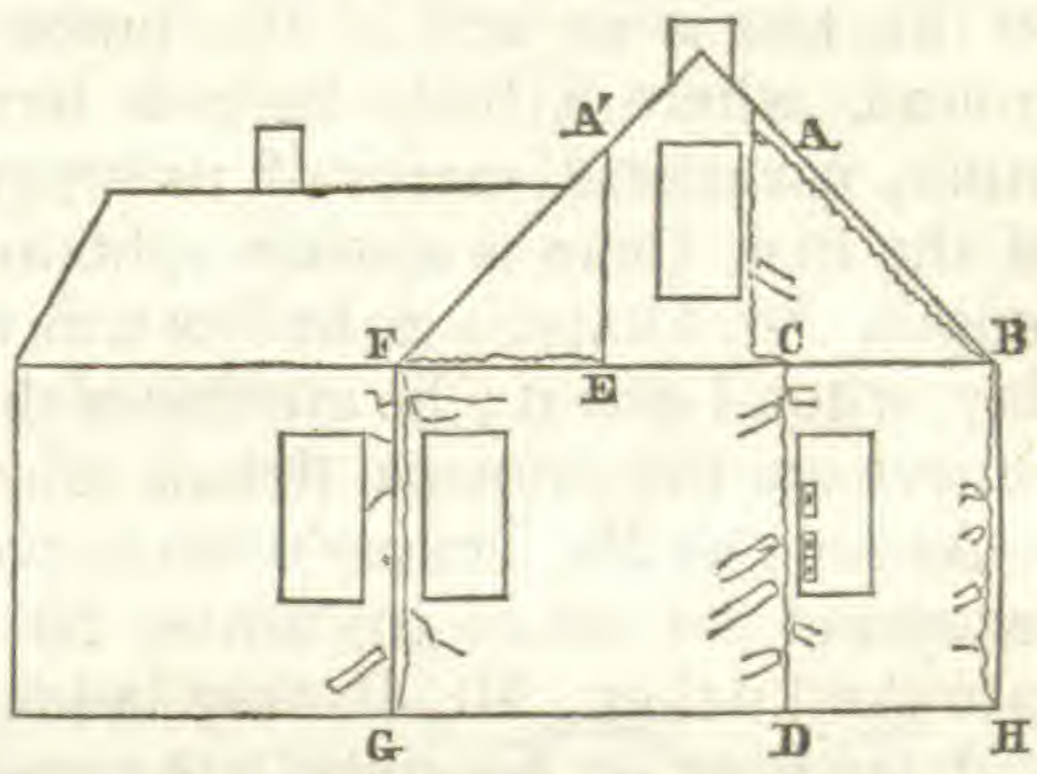


Fig. 1, on preceding page, represents a ground plan of the premises: A, front door which opened into the entry E; B, front room; C, kitchen; *ch*, chimney; *e*, old fashioned clock, reaching from the floor near to the ceiling; *f*, seat of Mr. Draper by the clock; *g*, seat of Mr. Barney; *h*, seat of Mrs. Draper; *i*, seat of Mr. Draper's daughter; S, stove; *c*, door leading out of the kitchen into back entry E′; *p*, post on which hung a mirror; T, T, Balm of Gilead trees; W, well.

The house was first struck at A, fig. 2, whence the fluid passed into the house and divided; a part going down the stud A C, and thence down the stud C D to the ground; the other part went down the rafter A B, and thence down the post B H, to the ground. The part which went down A C ran along the stud from A till it came to a long iron spit about three feet long, down this it passed to its point which rested on the beam F B, thence along the beam a short distance to the stud C D, down which it went, tearing off several clapboards in its progress on the outside of the house, and the laths, plastering and paper, beside the window, on the inside. It also broke from the window three lights of glass, throwing the glass *into* the house. The white oak stud C D was split its entire length, the fluid following the rows of nails which fastened the laths, clapboards, &c. That portion of the fluid which went down the rafter A B split off the weather board from the rafter, then passed down the post B H a short distance till it came opposite the wheel-work of the tall old fashioned clock which stood in the corner at *e*, fig. 1. From the post it passed to the top of the clock to the wheels, tearing off the upper part of the clock-case and throwing it into the middle of the room B, fig. 1. From the wheels, it passed down the long iron pendulum, thence through the bottom of the clock-case into the corner of the house and into the ground. The glass in the upper part of the clock-case was broken, and the case at the bottom was badly splintered, but the clock was not stopped.

2.



VIEW FROM THE N. E.

Mr. Draper, who was sitting in the chair at *f*, fig. 1, was prostrated by this part of the shock into the middle of the room, on his face. There was no visible mark of injury on him at the time, although he complained at first of numbness in his lower limbs, then of a severe burning sensation in his feet, and requested that his "boots might be taken off, for his feet were burning up."

There was a bruise at the corner of his left eye and another on the back of his right hand, but these he thinks were not made by the lightning. The clothes which he had on at the time were entirely of cotton and were uninjured. The room was immediately filled with a very strong smell of sulphur. There was a small hole made in the back right-hand corner of the flag-bottomed chair in which Mr. Draper sat. No other person in the room was in the least injured by this stroke.

It appears that a part of the fluid passed down the tree situated at that end of the house. The first visible effect of the lightning on this tree is on one of the limbs about twelve feet from the ground, where a little bark is torn off; from that spot to the trunk, occasional marks of its progress are visible; on the trunk of the tree, there is a seam split in the bark about four feet in length. Mr. Draper's right foot was very much swollen on the next day, when I saw it; he attributes this to his first shock. These I believe are the principal details relative to the first shock.

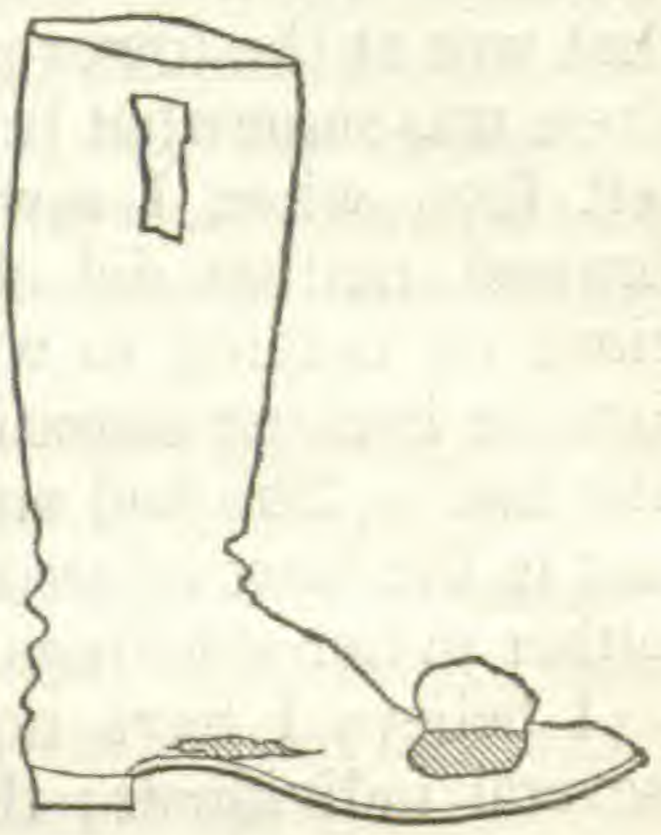
As soon as Mr. Draper's boots were off and he had somewhat recovered the use of his limbs, he was assisted by those present into the kitchen, Mr. Barney being on his left side and his wife and daughter on his right. As soon as he was seated in a chair (about four feet from the post *p* (fig. 1,) in the kitchen, the second flash came and prostrated all four of them. This flash struck the house on the roof, close to the edge and directly over the rafter at A′, fig. 2, where there were four iron hooks hanging; from these it passed down the stud A′ E, on which was hanging a long iron rod; thence it went to an iron pan which rested on the beam, leaning against the side of the house; from the pan it ran along the beam in the direction E F, fig. 2, till it came to the post F G, (*p*, fig. 1,) down which it went, tearing off the casing on both sides, breaking to atoms a mirror which hung on the post, splitting the post, which was of white oak, its entire length, tearing off the laths on both sides of the post on the inside of the house, and the clapboards on the outside; it then passed into the floor, after which but few marks of its progress are to be seen. There are a few places over-head in the kitchen where the plastering is torn from over the nail-heads. A few splinters are torn from the floor of the entry which leads out of the kitchen, and some out of the kitchen floor, near to the door of the entry.

The effect of the stroke upon Mr. Draper's daughter, although she is a lady about 45 years of age and in very feeble health, was but slight; and being merely stunned she soon recovered. Mr. Draper was also stunned, and more so than at his first shock; but he thinks he received no additional injury.

The effect upon Mrs. Draper and Mr. Barney was more severe. A portion of the fluid passed from the post *p*, fig. 1, to Mr. Barney, (he being nearest the post and distant about four feet,) strik-

ing him on the outside of his left hip, then running round on the front of his hip in a spiral manner to the inside of his left leg, ripping open the inner seam of the left leg of his pantaloons for about eight inches as it passed down his leg. It tore off a piece of skin above the ankle, then passed over the ankle and tore off the skin from just below the ankle to the first joint of the great toe, where it passed out through the boot, tearing out a ragged, nearly round piece of the size of an American dollar. Another portion passed out nearer the heel, making a ragged slit two inches in length. Fig. 3, represents the appearance of Mr. Barney's boot. The piece of leather was not detached on the upper side. He had on no stocking at the time. Mr. Barney was the first of the four who came to a state of sensibility; he immediately crawled to the door *d*, fig. 1, and called for assistance (there being a house within about three rods.) He at first complained of an intense burning sensation, and requested that his boots might be taken off. The foot, on taking off the boot, was found to be very black, and the leg above was colorless and numb, and for half an hour appeared like the limb of a dead person. The hip and whole leg along the track of the fluid, was very much scorched; and when I saw it the next day, about 5 P. M., the muscle under the track of the fluid was somewhat shrunken in appearance, and the skin very red.

3.



Mr. Barney says he heard the report but saw no flash. He had been at work in a field near the house of Mr. Draper, and seeing the shower coming up, went into the house to be out of the rain; he thinks he got into the house before it commenced raining, and that his clothes were perfectly dry unless his perspiration might have moistened them. His pantaloons were a pair of blue and white overalls. The *stitches* and not the cloth were ripped out at the knee.

Mr. Barney says that his wound "does not feel like a common burn but more like a scald." He says that he "has for some time past been troubled with a severe cough and soreness in his lungs, but that since he received the shock, he has not felt so sore at his lungs and his cough is much better."

Mrs. Draper (an old lady now in her 80th year) also received a portion of the fluid which came from the post *p*, fig. 1. She was in a state of insensibility for half an hour, although as soon as assistance could be procured, means were used to resuscitate her.

She was first struck on the back of her neck; the fluid there scorched the hair, then ran round her neck on a string of gold

beads which she had on at the time. Each bead must have been enveloped in the fluid, I think, as it passed around her neck, for the position of each bead was distinctly marked by a black spot on her neck, and the number of these black spots correspond with the number of beads. The effect of the fluid on the beads was to turn them black. She had in her ears at the time a pair of gold ear-nubs;—the one in her left ear had a spot on it similar to what would be made by putting strong acid on brass; it looked black and corroded. From her neck the fluid passed down her left side to her feet, leaving but one mark of its progress, and that was at the lower part of her chest on her left side; the skin there was somewhat bruised and blackened but not broken. Her left foot, when I saw it, was very much swollen, but was not bruised, neither did she complain of any soreness. Her sensations on coming to were the same as those of the others; an intense burning sensation in her feet "as though her feet were in the fire." She had on at the time a thin cotton dress, which was not in the least injured by the stroke. There was no rent made either in her stockings or shoes.

I believe I have now detailed the principal effects upon the several individuals; there are however some further particulars worthy of notice.

There were no marks made by the lightning on the kitchen floor where the four individuals were prostrated. There were no marks of the lightning near the stove, which was but about four feet from where the four individuals were standing at the time of the second shock. In the cellar little damage was done, except to remove the mortar from between the stones. In the chambers or attic above, there were several articles of iron furniture stowed in the end near to where the house was struck. Within four feet of where the lightning passed down the stud A′ E, fig. 2, there stood an air-tight stove which did not seem to have been in the least molested by the lightning. An old umbrella which lay at the foot of the stud A′ E, was set on fire but none of its metallic fixtures were melted.

The silvering on the back of the mirror which hung on the post *p*, fig. 1, did not seem to have been in the least affected by the electricity; still the frame of the mirror was very much shattered. The electricity, wherever it went, appeared to have made a very diligent search for nails, screws, hinges, &c., and wherever it found them, it either tore them out or split the wood around them.*

North Attleboro', July 18, 1851.

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* In the passage of electricity, the effects of violence are to be found mainly where the current is interrupted. A good metallic conductor, or masses of iron together would receive the fluid and might show no effects, but ranges of nails or spikes would give rise to a shock between them and consequent violence.—Eds.

Art. XXVII.—*On the former Changes of the Alps;* by Sir Roderick Impey Murchison, V.P.R.S.*

The complicated structure of the Alps so baffled the penetration of De Saussure, that after a life of toil the first great historian of those mountains declared "there was nothing constant in them except their variety." In citing this opinion, Sir Roderick explained how the obscurity had been gradually cleared away by the application of modern geology, as based upon the succession of organic remains, and then proceeded to indicate the accumulations of which the Alps were composed, and the changes or revolutions they had undergone, between the truly primeval days when the earliest recognizable animals were created, and the first glacial period in the history of the planet.

The object being to convey in a popular manner clear ideas of the physical condition of these mountains at different periods, three long scene-paintings, prepared for the occasion, represented a portion of the chain at three distinct epochs. The first of these views of ancient nature exhibited the Alps as a long, low archipelago of islands, formed in a great part out of the Silurian and older sediments which had been raised above the sea, when the lands bore the tropical vegetation of the carboniferous era.

Stating that there were no relics in the Alps of the formations to which he had assigned the name of Permian, as marking the close of the primeval or palæozoic age, Sir Roderick rapidly reviewed the facts gathered together by many geologists from all quarters of the globe, and maintained that they unequivocally sustained the belief, that there had been a succession of creations from lower to higher types of life, in ascending from inferior to superior formations. He carefully, however, noted the clear distinction between such a creed, as founded on the true records of creation, and the theory of the transmutation of species; a doctrine put forth in the popular work entitled the "Vestiges of Creation," and from which he entirely dissented.

In the second painting (an immense lapse of time having occurred) the Alps were represented as a mountainous ridge in which all the submarine formations, from the mediæval up to the older tertiary or Eocene, had been lifted up upon the flank of the primeval rocks. Each rock system being distinguished by a color peculiar to it, the nature of the animals contained in each of these deposits was succinctly touched upon. Between the youngest of the primeval formations and the oldest of the mediæval or secondary rocks, it was stated, that there is not one species in common to the two in any part of Europe; the expression being

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* Proc. Roy. Soc., March 7, 1851, p. 31.

that "an entirely new creation had succeeded to universal decay and death."

In speaking of the Alpine equivalents of the British Lias and Oolites, Sir R. paid a deep-felt tribute to Dr. Buckland, who thirty years ago had led the way in recognizing this parallel; and Leopold von Buch was particularly alluded to as having established these and other comparisons, and as having shown the extent to which large portions of these mountains have been metamorphosed from an earthy into a crystalline state. In treating of the cretaceous system it was shown that the Lower Green Sand of England, so well and so long ago illustrated by Dr. Fitton, was represented in the Alps by large masses of limestone, since called Neocomian by foreign geologists.

Emphasis was laid upon the remarkable phenomena, that every where in the south of Europe (as in the Alps) the Nummulite rocks, with the 'flysch' of the Swiss, and the 'macigno' of the Italians, have been raised up into mountains together with the Hippurite and Inocerami rocks, or the chalk on which they rest; and hence it was, that before Sir R. made his last survey of the Alps, the greater number of geologists classed the Nummulite rocks with the cretaceous system, and considered them both to be of mediæval or secondary age. But judging from the fossils which differ entirely from those of the chalk (except at the beds of junction) and also from their superposition, he had referred these Nummulite rocks to the true lower tertiary or Eocene of Lyell. Beds of this age, though once merely dark-colored mud, have been converted into the hard slates of Glarus with their fossil fishes (among which eels and herrings first made their appearance); other strata of this date contain the well known fishes of Monte Bolca; and others again have been rendered so crystalline amid the peaks of the Alps as to resemble primary rocks, so intense have been the metamorphoses!

Dwelling for a few minutes on the atmospheric conditions which prevailed after the elevation of the older tertiary, Sir R. inferred that a Mediterranean and genial climate prevailed during all the long period whilst the beds of sand (Molasse) and of pebbles (Nagelflue) were accumulating under the waters both of lakes and of the sea, and when derived from the slopes of all the pre-existing rocks. The marine portions of the Molasse and Nagelflue contain the remains of many species of shells now living in the Mediterranean; whilst in alternating and overlying strata, charged exclusively with land and fresh water animals, not one species among many hundreds, including numerous insects, is identical with any form now living. This point, on which he first insisted on his return from the Alps in 1848, Sir R. had considered to be of paramount importance in proving, that terrestrial life was much less endowed with the capacity to resist physical

changes of the surface than submarine life: for here we have a fauna which is Pliocene in the order of the strata, and yet is not Eocene in its animal and vegetable contents.

A certain number of the more remarkable animals that lived during this younger tertiary age were then adverted to, such as the Rhinoceros and other large quadrupeds, the fossil Viverrine fox (the original of which was on the table,) the huge Salamander (Andrias Scheuchzeri) and a Chelydra which had been described as analogous to the snapping turtle of the southern states of North America. These, with quantities of plants, including small palms, were all indicatives of a warm and genial climate; and on such sure grounds the second diagram placed the Alps before the spectators as covered with a suitable vegetation, and with several of the above mentioned animals in the foreground.

Having satisfied himself, in common with M. Studer, M. Escher, and all the geologists who have well explored the Alps, that every where along the northern flank a terrific dislocation has occurred, amounting in many places to a total inversion of mountains, between the older tertiary and those younger deposits which were accumulated under the waters during the period he had just been describing, Sir Roderick then briefly pointed out what he had demonstrated in detail elsewhere: viz. that the sands and pebble-beds of that age had been suddenly heaved up from beneath the waters all along the outer or northern flank of the chain, so as to form mountainous masses, the inverted and truncated ends of which had been forced under the edges of the very rocks out of whose detritus they had been formed.

Before this great revolution had taken place, no large erratic blocks were known, but after it, they became common, and were the necessary production of that intensely cold climate to which the Alps were then subjected; a change, of which their surface bears distinct evidence.

During the same period, the low countries of northern Europe were covered by an Arctic sea. If such waters then extended to the Jura and the Alps, icebergs and rafts must have been detached from the latter, carrying away blocks of stone northwards, to be dropped at intervals, just as it has been demonstrated that the Scandinavian blocks were dropped in Prussia, Poland, and the low lands of Russia, when all those regions were under the influence of an Arctic sea. Bavaria, and the lower parts of the Cantons Vaud, Neufchatel, and Berne, were, it is supposed, then covered by waters which bathed the foot of the Alps.

That the change from a former genial climate to the first great period of cold was a sudden one is further sustained by the fact, that the inclined strata in which the Mediterranean animals are buried, are at once covered *transgressively* and *unconformably* by other beds of gravel, shingle, and mud, in which the remains of plants and animals are those of a cold climate.

The third scene, therefore, exhibited the sands and pebbles of the genial period thrown up into mountains on the flanks of the chain, the peaks of which were probably covered for the first time with snow, and from the openings of which, whether protruding to the sea-shore or into deep fiords or bays, glaciers and their moraines advanced, from which icebergs or rafts were floated away as suggested.

In concluding Sir Roderick thus expressed himself:—"Having thus now conducted you rapidly through the most prominent changes which the Alps have undergone, from the first period when they had emerged, probably as an archipelago of low islands in a tropical climate, to that epoch when the animals and plants living upon them indicated a Mediterranean temperature, and then to that Arctic period, the conditions of which I have just been discussing, I have no longer to call for your assent to any inferences of the geologist, which all of you are not perfectly competent to understand.

"To convert the Alps of the earliest glacial period into the Alps of the present day, you have only to figure them to yourselves, as raised 2000 or 3000 feet above the altitude which they are supposed to have in the diagram last exhibited. All their main features remaining the same, you would then have before you, the present Alps and their valleys, irrigated by lakes and rivers instead of bays; and in place of the waters sketched in beyond them as in the painting, with ice-bergs floating upon them, you will then have dry mounds of gravel, sand, and blocks, which were accumulated under the former waters; such, in a word, as now constitute low hills and valleys and all the richest land of Switzerland and Bavaria, where man has replaced the rhinoceros and turtles of one period, and the icebergs of another. You who have not visited this noble chain, and who wish to judge of its gorges, peaks, and precipices, have only to consult the views of our associate Brockedon, in order to have nature in her present mood, brought in the most telling manner before you. But those of you who really wish to grapple with the geological wonders of former days, may look at the flanks of the Rigi from the lake of Lucerne, whence, even from the deck of the rapidly passing steamer, you will see how that great pile of pudding-stone, every pebble of which has been derived from rocks in the chain more ancient than itself, has been lifted up from beneath the waters in the manner represented; whilst if you continue the same traverse up the Lake to Altorf, you will pass by numerous extraordinary folds and breaks of the secondary limestones, and of the older Tertiary or Nummulitic rocks. Such a doubling or crumpling up of these strata, you may then perchance agree with me in thinking, was in a great measure the result of lateral pressure between two great masses; the crystalline centre of the chain upon the south, and the newly upraised deposits on

the north of which the Rigi is a small part only, which latter having been intruded upon the terrestrial surface, necessarily compressed the pre-existing formations into a smaller compass. If more adventurous, you should climb to peaks rising to 8000 or 9000 feet above the sea, that flank the central summits, you may there satisfy yourself, that deposits, which were once mere mud, formed during the same time as our slightly consolidated London clay, have been in many parts converted into schists and slates as crystalline as many of the so-called primary rocks of our islands. So intense has been the metamorphosis!

"In speaking of the last changes of the Alps as stupendous, I know it may be said that, in reference to the diameter of the planet, the highest of these mountains and the deepest of these valleys are scarcely perceptible corrugations of the rind of the earth. But when we compare such asperities with all other external features of this rind, they *are* truly stupendous. How, for example, can the observer travel over vast surfaces such as Russia, and not be able there to detect a single disruption—not one great fracture, and no outbursts whatever of igneous and volcanic rocks; but on the contrary, a monotonous and horizontal sequence of former aqueous deposits, which, simply dried up, have never been disturbed by any violent revolutions from beneath, and then compare them with the adjacent Ural mountains, or still better with the loftier Alps, and not be impressed with the grandeur of such changes?

"And here my auditors will recollect, that even beneath and around this metropolis they can be assured by finding extinct fossil mammalia, that such also have been the changes, though on a less scale, in our own country. The large extinct British quadrupeds necessarily required a great range for their sustenance. They had doubtlessly roamed from distant tracts to our lands before the straits of Dover were formed and before the British dominions were broken into isles. Our great insular dislocations were, I conceive, coincident with that striking phenomenon in the Alps on which I have tried to rivet your attention, when the first glacial and icy period affected so large a portion of this hemisphere, and when large portions of our northern lands formed the bottoms of an Arctic sea. But such tracts were bidden to rise again from beneath the waters and constitute the present continents and islands before man was placed on the surface. Our race, in short, was not created until the greater revolutions of which I have treated had passed away.

"These grand dislocations belong, therefore, distinctly to former epochs of nature, and their magnitude *is* enormous when compared with any thing which passes under our eyes, or has been recorded in human history. At the same time geologists have shown upon clear evidences, that during the long and com-

paratively tranquil former period which intermitted with geological revolutions, there was a constant exhibition of diurnal agencies similar to those which prevail in the present world. In those older times, rain must have fallen as now,—volcanic forces must have been active in scattering ashes far and wide, and in spreading them out together with sheets of lava beneath the waters,—gradual movements of oscillation and moderate elevations and depressions must have occurred,—long continued abrasion of the sides of mountains must have produced copious accumulations of 'débris' to encroach upon lakes, the overflow or bursting of which may have sterilized whole tracts.

"All such and many more modifications of the ancient surfaces of the globe, including many slight breaks in the long career, were doubtlessly common to all epochs. But whilst no such operations can be compared with those phenomena of disruption and overturning of mountain masses which have been specially dwelt upon this evening, so also according to my view it is impossible, that any amount of small agencies, if continued for millions of years, could have produced such results.

"In thus attempting to shadow out in the space of an hour all the chief formations and transmutations of a chain like the Alps, I have probably labored to effect what many persons may deem impossible; but I have thought that some at least of these evening discourses should awaken the mind to the larger features of each science, the details of which must be followed out in courses of lectures. I would beg, therefore, those persons who have not studied geology practically, to dwell chiefly on the facts brought forward, and to believe that they are indisputably and clearly proven. They tell us unmistakably how different creations of animal and vegetable life are entombed in these vast monuments of ancient nature, and they reveal to us that each creation of the successive inhabitants of the surface lived during very long periods of time. They announce to us, in emphatic language, how ordinary operations of accumulation were continued tranquilly during very lengthened epochs, and how such tranquillity was broken in upon by great convulsions.

"Being thus led to ponder upon the long history of successive races and also upon some of the most wonderful physical revolutions the chain has undergone, we cannot avoid arriving at the belief, that, in addition to many other great operations, the disruption which upheaved the middle and younger Tertiary formations from beneath the waters, and threw them up into mountain masses accompanying the production of the first great arctic period known in the history of the planet, was a change of immeasurable intensity. That change, in short, by which a period of snow, ice, glaciers, floating icebergs, and the transport of huge erratics far from the sources of their origin, suddenly followed a genial and Mediterranean clime!"

Art. XXVIII.—*Observations on the Pendulum Experiment;* by Rev. C. S. Lyman.

Every one who has repeated the interesting experiment of M. Foucault for exhibiting the rotation of the earth, has noticed the tendency of the pendulum, after vibrating awhile apparently in a straight line, to acquire gradually an elliptic motion. The quantity of this ellipticity in different experiments is very variable, some observers having found it to amount occasionally to half an inch or an inch for the minor axis, when the pendulum was left to vibrate for a considerable time. If the experiment, however, is skillfully conducted, the degree of ellipticity will always be small, and when it is not so, it may safely be attributed to imperfections in the apparatus, currents of air, lateral vibration of the pendulum at the moment it is disengaged, or other like sources of disturbance. In our own experiments, to which we shall again refer, with an apparatus by no means answering to our wishes, the minor axis of the ellipse rarely exceeded two-tenths of an inch, with an initial arc of vibration of about four feet, and in some trials no ellipticity was perceptible for the first two hours. Whether it is possible to conduct the experiment so skillfully as entirely to avoid these sources of error, and cause the pendulum to vibrate without any observable ellipticity arising from such accidental causes, is very doubtful. Certainly no one has yet succeeded in doing it.

But even if the conditions of the experiment were theoretically *perfect*, that is, the apparatus free from all defect, and uninfluenced by accidental disturbing causes, still the ball would never move in a straight line from side to side, but always necessarily describe an ellipse, in consequence of the rotation of the earth itself. It seems to have been taken for granted by those who have written on the subject, that, in theory, the pendulum ball at each vibration should pass accurately through its point of rest, or a vertical straight line drawn from the point of suspension to the center of the earth. And this is stated in so many words on page 562, vol. i, No. 7, 4th ser. of the Philosophical Magazine, in remarks by Rev. Baden Powell before the Royal Institution. That this would be true had the earth no rotation on its axis, is obvious. But a little reflection will make it evident that in existing circumstances, such can never be the case.

Suppose, to simplify the problem, the experiment to be performed at a pole of the earth. The point of suspension of the pendulum, and the center of the circle over which the pendulum vibrates, being in the line of the earth's axis are unaffected in position by the earth's rotation. But the circumference of the circle, and with it the pendulum ball when drawn aside and de-

tained over it previous to being let off, obviously partake of the earth's motion of rotation, making a complete revolution around the pole, or center of the circle in twenty-four hours. The pendulum ball has thus a certain momentum, or amount of motion at right angles to the plane of vibration, at the moment it is disengaged; which motion, during the time the ball is descending from the circumference to the center of the circle, must carry it to the right hand, or aside from that center by a space corresponding to the tangential velocity it possessed at starting. Continuing its curvilinear motion under the action of gravity and the tangential force referred to, it proceeds by the laws of central forces to complete approximately an ellipse, with the point of rest for its center.

The same elliptical motion which would thus necessarily exist at the poles, must occur likewise on any other part of the globe, except at the equator. For in any given latitude, it is easily demonstrated, that the graduated horizontal circle across which the pendulum vibrates, possesses a virtual motion of rotation in azimuth about the vertical, in consequence of the earth's rotation—the amount of its angular motion in a given time being equal to the angular motion of the earth on its axis in the same time multiplied by the sine of the latitude, as has been shown by many writers on the subject.

This relative azimuthal motion of the horizontal circle around its center, is precisely that of which the ball partakes at the moment it is disengaged, and from which must arise a necessary ellipticity, just as in the case at the pole, only less in amount by as much as the sine of the latitude is less than radius.

Perhaps this motion may be more readily conceived, by considering, that points on the earth's surface rotate eastward with different velocities as they are at a greater or less distance from the equator; consequently, that the south point of the horizontal pendulum circle moves eastward with a greater velocity than the center, so that when the pendulum ball is released from that south point, retaining the full amount of its eastward motion, instead of passing directly through the center, or point of rest, it must leave it behind, passing it to the eastward by a space equal to the difference of the motions of the two points during a semivibration.

The same will hold true in whatever direction the pendulum is made to vibrate. For, suppose the ball drawn to the eastern side of the circle: though in this case the actual rotary velocities of the center of the circle and of this eastern point of it are the same, considered as around the earth's axis, yet considered as around the vertical, with which in these experiments we have to do, they are quite different. It has already been shown that the *south* point of the circle has a relative azimuthal motion in re-

spect to the center. The east point, being constantly at right angles to the south point, must consequently have a like relative motion. And so of every other point in the circumference of the circle. Hence, from whatever point the ball is let off, it must possess a tangential motion relatively to the center, and therefore move in its vibrations in an elongated ellipse.

Nor are we to regard this necessary ellipticity, though minute, as too small for detection, where the experiment can be carefully performed under favorable circumstances—particularly with a long pendulum, and a large arc of vibration.

Suppose the pendulum 208 feet in length, making a vibration in 8 seconds or a semi-vibration in 4 seconds. Suppose the arc of vibration 20 feet, or the radius of the circle 10 feet. A point in the circumference of this circle would, in the latitude of New Haven, have a motion relatively to the center of 40″ of arc in 4 seconds of time, or a semi-vibration; which 40″ on a circle of 10 feet radius will be equal to 0·022 of an inch. Thus giving for the minor axis of the ellipse double this quantity, or nearly the twentieth of an inch. This space would doubtless be readily appreciable in a delicate arrangement of the experiment on the scale supposed; or if not appreciable at once by direct observation, would be likely to develop itself, as experiments were multiplied, by showing the elliptical tendency to be in one direction rather than the other.

The ellipticity arising from the earth's rotation must, as we have seen, always be towards the East, or in a direction opposite to that of the hands of a watch. But the ellipticity observed in the experiments is in both directions—showing that in general it must be owing to other causes than the one specified. Indeed, in the ordinary experiments, with pendulums comparatively short, and a small arc of vibration, this ellipticity must be entirely inappreciable by direct observation. It can only become obvious, if at all, in experiments on a large scale; and so far as appears, persons who have conducted such experiments have not had their attention drawn to this particular point. It is partly with a view to invite the attention of more favored experimenters to the subject, that this article has been written and the results given of our own imperfect experiments.

These experiments were instituted in part, to determine whether the ellipticity of which we have spoken could be made appreciable by the facilities within our reach. The pendulum we have used is a cylinder of lead on a iron axis, very accurately turned, and weighing 12 pounds. This is suspended by a fine brass wire soldered at its upper extremity into a brass bolt inserted in the apex of the dome, or skylight, of the State House in New Haven. The length of the pendulum is 71 feet, (vibrating once in $4\frac{2}{3}$ seconds,) and the diameter of the graduated circle placed beneath

it 36 inches. Owing to the closeness of the entire apartment, little or no trouble was experienced or apprehended from aerial currents.

Without giving the experiments in detail, we will only mention some of the results.

The pendulum was usually set vibrating with an arc of about four feet, which in half an hour became reduced to 28 inches, in an hour to 19 inches, in an hour and a half to 14 inches, in two hours to $10\frac{1}{2}$ inches, in three hours to $6\frac{1}{2}$ inches, and in four hours to $4\frac{1}{3}$ inches. In general the duration of the experiments was not much over an hour, often much less, occasionally three or four hours.

As to the amount of ellipticity, there were but two instances out of over thirty in which none could be perceived. In several other cases it was barely perceptible after the lapse of two or three hours, and in but one instance exceeded two-tenths of an inch for the minor axis. In general it was less than one-tenth of an inch at the close of the experiment.

As to the motion in the ellipse, it was by no means always in the same direction, and hence could not be due exclusively, at least, to the influence of the earth's rotation. It seemed rather to depend on some imperfection of the wire at the point of suspension, or some other defect of the apparatus, inasmuch as it appeared to have a pretty uniform connection with the direction across the circle in which the pendulum vibrated. For example, six times when that direction coincided with the meridian the motion in the ellipse was with the hands of a watch. The same number of times when put in vibration at right angles to the meridian, the motion was in the contrary direction. When vibrating from N.E. to S.W. the motion was with the hands; when from N.W. to S.E. the reverse. And these results were nearly uniform while the point of suspension retained a given position in reference to the points of the compass, but when that position was altered, the points at which a given direction of elliptical motion was observed were changed also; showing, as before remarked, that the direction of elliptic motion was connected not with the rotation of the earth, nor with the points of the compass, but with something in the apparatus itself; and it probably depended not on any imperfection in the ball of the pendulum, but in the wire above at the point of suspension. The necessary ellipticity of rotation was not detected in these experiments, being doubtless over-balanced and lost amid the more efficient causes of ellipticity arising from accidental sources.

As to the rate of angular deviation of the plane of vibration on the graduated circle, this was observed to be obviously affected by the direction in which the pendulum moved in its elliptic orbit—being accelerated when that motion coincided with the

motion of the plane of vibration, and retarded when the reverse; and the amount of this acceleration or retardation was not constant in a given case, but increased as the arc of vibration diminished and the ellipse became less eccentric. Sir John Herschel has shown* that when a pendulum, as in these experiments, moves in an ellipse, the line of apsides of that ellipse will necessarily have a progressive motion in the same direction in which the pendulum revolves; and this motion will be more or less rapid according to the angular extent of the arc of vibration. When that angle is indefinitely small, the sines of the angles made by the pendulum wire with the perpendicular, which sines represent the intensity of the central force by which the motion of the pendulum is governed, will be nearly in the proportion of the arcs themselves, and the line of apsides of the ellipse will remain immovable. But when the arc of deviation from the vertical is considerable, the sines cease to be proportional to the arcs, and as the pendulum approaches the extremity of its vibration, being acted on by a diminished central force, it is suffered to go past the point on the circle at which in the preceding revolution it turned the extremity of the ellipse, before it is brought to do the same again, and hence the line of apsides must revolve in the same direction. This accords with our experiments.

The mean hourly motion of the plane of vibration, when the direction of the elliptic motion coincided with it, was 10° 11′. When it did not coincide, 9° 44′—giving a mean hourly motion of 9° 57′. The theoretical hourly motion in the latitude of New Haven would be 9° 54′. This amount of motion as deduced from experiment would doubtless have been somewhat modified had the experiments been more numerous, and they are only here given as a first approximation. The numbers show very clearly, however, the accelerating and retarding effect of the elliptic motion.

It should be remarked, that if the necessary ellipticity which we have considered to arise from the earth's rotation has any influence on the results of experiments, it should tend slightly to retard the motion of the plane of vibration, inasmuch as being always in the direction of the earth's rotation, it should give the line of apsides of the ellipse a motion in the same direction; which motion would have to be deducted from the motion of the plane of vibration in the opposite direction. Whether accurate experiments will show such a retardation remains to be seen. So far as experiments have been tried, in some cases, as at Paris, they seem to indicate such a result, while in other cases they do not.

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* Outlines of Astronomy, p. 421, Am. Ed.

Art. XXIX.—*Miscellaneous Notes, from Europe;* by B. Silliman, Jr.

1. *Present condition of Vesuvius.*

The eruption of Vesuvius in February, 1850, and that of the year previous, entirely changed the summit features of this ancient mountain of fire. The former crater disappeared, being filled with scoria and ashes, while *two* craters now occupy the summit of the cone. The deepest and most active of these is that of February, 1850, which is situated on the side of the cone nearest to Pompeii. It is somewhat lower and has a much greater depth than its immediate neighbor, which is on the side of the bay of Naples. We had no means of measuring its depth accurately, but judging from the time required for the returning sound of a stone cast into its mouth, as well as from inspection and comparison, we assumed the depth of the new crater to be from 800 to 1000 feet. It is acutely funnel-shaped at an angle of not less than 60°. It is impossible, because of the steam and vapors of sulphurous acid, to see its bottom, even if not prevented by the danger of the descent to a position where one might hope to catch a glimpse of its bottom. Its activity at present is confined to the emission of vapor, and even this seems at times, when viewed from the sea, to be wanting. On the summit, however, these vapors appear dense enough and are sufficient to prevent the possibility of making the entire circuit of the crater. From this cause we were unable to examine the lip dividing the crater of 1850 from its neighbor. The observer is much struck not only with the change of form in the summit as shown by the drawings of Prof. Scacchi, but also with the sharpness of the lip of both craters, which is such that it is hardly possible for more than two persons to stand abreast upon it. During the late eruption, the lava found vent from the base of the cone on a level with the sand plain which fills the ancient crater of Somma. It here poured out a torrent of scoriaceous red lava through a well defined canal. This is now entirely cold, and we collected from its sides abundant specimens of aphthitalite, which frosted over the rugged cavern like snow. Near this spot also are two fumeroles formed during the last eruption; the largest about 25 feet high, with an aperture of near ten feet, its outer walls black, rugged and forbidding. The flow of lava from the eruption of 1849 was in the direction of the ancient Pompeii, and it was copious enough to destroy a small village with its vineyards, at the distance of several miles. The king of Naples has since erected a new village for the unfortunate inhabitants near the site of the former one.

During the past six years the king of Naples has also constructed a carriage road up the side of Vesuvius as far as the Hermitage, where he has a Royal Meteorological Observatory, under the direction of the celebrated Melloni. This road follows in a very serpentine path over and around the hill of ashes, which all who have seen Vesuvius will remember as forming a remarkable feature in its topography. In this manner, sections have been opened in the hill for a distance of three or four miles, and were these viewed without reference to the immediate

proximity of the volcano which has produced the deposit, it would be easy to refer the whole to an alluvial origin, so characteristic are the undulating lines of deposition, the alternation of coarse and fine materials interstratified, including now large angular masses of rock, and again graduating into the finest silt and mud. In some places the lines of deposition are curved in regular undulations, and in others they meet at a sharp unconformable angle. Close observation alone detects that the whole material is volcanic—pumice, scoria, sand and fine dust, including large blocks of inflated lava and tufa.

It is impossible to see any difference in the general character of these deposits and of those which cover Pompeii, only that the latter being mostly the result of one eruption are less varied than the former, and more regularly stratified. In both, the evidence of aqueous action is very obvious; and we have historical as well as geological evidence of the eruption of vast volumes of aqueous vapor with the lapilli, scoria and fine ashes from Vesuvius, which, condensing into rain, produced a deluge of hot mud, filling the most intricate recesses of the Pompeian houses and producing the appearance of an aqueous deposit in the ash hills of the flanks of Vesuvius. In Herculaneum we see the same phenomena in a more remarkable manner. Here owing to a much larger accumulation of material—to subsequent overflows of lava and the superincumbent weight thus produced, with the aid of water, the ashes were consolidated into so compact a mass that some writers have even doubted whether Herculaneum had not been destroyed by an overflow of lava in the first instance. That such was not the fact is well known, and the condition of the antiquities imbedded there quite forbid the idea were no other evidence attainable.

2. *Grotto del Cane and Lake Agnano.*

The Grotto del Cane or dog grotto, has been so much cited for its stratum of carbonic acid gas covering the floor, that all geological travellers who visit Naples feel an interest in seeing it. Unfortunately, like some other grottos, its enchantment disappears on a near view. It is a little hole dug artificially into the foot of a hill facing Lake Agnano. The aperture is closed by a door, and the space within is barely sufficient for one person to stand erect. Into this narrow cell a poor little dog is very unwillingly dragged and placed in a depression of the floor, where he is soon narcotized by the carbonic acid. The earth is warm to the hand, and the volume of gas given out is very constant. Such is the world-renowned Grotto del Cane, which if it did not equal our anticipations, at least afforded us the opportunity of some merriment!

Lake Agnano, as is well known, fills the bottom of an ancient crater whose walls are still distinctly to be traced. On the shore of the lake immediately opposite the Grotto del Cane there is a constant and copious discharge of carbonic acid, and the water of the lake at that part is in great agitation from its escape. Nor is other evidence wanting of the present operation of the ancient causes which have characterized this region. At the foot of the hill on the east are numerous vents of steam and sulphur. Over some of these, vapor baths (Sudatoriæ) have been established, which are held in some repute in cases of rheuma-

tism. Digging a short distance into the hill near the ruins of the Villa of Lucullus, it is easy to perceive the presence of volcanic energy in the hot vapors accompanied with sulphur which issue copiously from the surface. The villa of Lucullus was entirely buried in lapilli and volcanic ashes, proceeding as is supposed from a vent in the immediate neighborhood; but from which vent does not appear—evidently not from the one now containing Lake Agnano, since that has not been active in the historic period.

In another cavity excavated in the hill near to the Grotto del Cane, is an abundant flow of carbonic acid, accompanied as is said by ammonia—but we did not perceive any odor of this gas nor any deposit of carbonate of ammonia or of sal-ammoniac on the walls of the place.

3. *Sulphur Lake of the Campagna, near Tivoli.*

The celebrated sulphur lake of the Campagna, near Tivoli, the Aquæ Albulæ of the ancients, still retains its interest to the geologist as the most remarkable of all the thermal sources of Italy. Whether we regard the constancy of the flow from it both of water and of gas, the area of the lake, or the important part which it and similar craters appear to have played in the formation of the travertine of the Campagna—we must admit that it is worthy of attentive consideration.

In the days of Father Kircher this lake was described as being over one mile in circuit. Now the lake is not over 500 or 600 feet in diameter, and its area is constantly diminishing. The baths of Agrippa which are now at a short distance from the shore, show the extent to which this contraction has taken place in that direction, since they were erected in the waters of the lake which were much esteemed by the ancient Romans for their hygienic effects. These baths were frequented by Augustus and enlarged by Zenobia; the latter spent her Roman servitude in Tivoli, and in allusion to this, they are still called "Bagni della Regina." At present the waters are conducted from this lake by a canal artificially cut in the travertine by Cardinal Ippolito d'Este, former governor of Tivoli, for a distance of two miles. This canal is nine feet wide and four feet deep, and there is a constant discharge of the surplus waters through it in a very rapid current—the volume of which is remarkable when we notice the small size of the source.

The strong odor of sulphuretted hydrogen announces the existence of this lake a long time before the traveller reaches it. The water was examined by Sir Humphrey Davy, who found it to contain one volume of carbonic acid, and less than $\frac{1}{2}$ volume of sulphuretted hydrogen. Tracing the canal from where it escapes the "Via Appia nova" up to the lake, a mile and a quarter, the observer is much struck with the copious escape of large volumes of gas from the whole surface of the lake, which is such as to convey the idea of ebullition. A stone cast into the water is soon followed by a very violent escape of gas, causing the whole adjoining area to boil with great energy and a loud sound of effervescence. The water is very clear, a slight milky or opaline appearance it has being due, as we thought, to the reflection of the white sides and bottom of the lake. Its temperature is 80° F., and it

has, when drank from a glass, an agreeable pungent taste of free carbonic acid—with no more of sulphuretted hydrogen than is pleasant. It is perfectly clear in the glass and effervesces briskly. The escape of gas does not appear to be confined to any particular part of the bed of the lake, but takes place equally over all its surface. The grass and reeds which grow luxuriantly at its margin are constantly encrusted with carbonate of lime from the water, and it is from this cause that the area of the lake appears to have been contracted, and not from any partial drainage which is evidently inexplicable since the level of the lake is now only a few inches below that of the adjoining and level Campagna. Breaking off a mass of grass and clods from the shore it was found that the roots of the plants were also encased, while the stone walls of the fields adjoining were wholly composed of loose blocks of travertine made up entirely of casts of the stems of growing grapes and aquatic plants. It required but casual observation of the travertine in other and distant parts of the Campagna to detect the same species of plants imbedded in every part of its mass. Blocks of travertine in the Coliseum at Rome and other ancient buildings also showed us the same evidence. A large space on the Campagna near the sulphur lakes lately fell in, owing to the cavernous and unsupported nature of the rock, and it was easy to see in the freshly fractured portions of the rock the same stems of aquatic plants, such as now grow on the margin of the water.

It is perhaps too much to infer from these casual observations so wide a deduction as that all the travertine is due to this origin from sulphur waters charged with bicarbonate of lime; but it is not going farther than is allowed by a prudent philosophy to say that travertine is now forming on the shores of Lake Solfatara from this cause.

4. *Meteorological Observatory of Mount Vesuvius.*

The Meteorological Observatory recently erected at Mount Vesuvius was projected by Prof. Melloni, so well known to all the world by his memorable researches on heat, and the most distinguished of all the Italian physicists. The King of Naples gave the enterprise his sanction, and furnished the means to construct the building. The house is of ample dimensions, standing on an artificial terrace at the summit of the hill of ashes which forms the limit of the arable region of Vesuvius, and at an elevation of about 2000 feet. The centre has three floors above the basement, and the two wings each one floor above the basement; in the rear and joining the main building is a round tower, and the roofs are conveniently arranged for meteorological purposes. All the plans were furnished by Prof. Melloni, who also superintended its erection, which by an inscription on the exterior appears to have been begun in 1841.

Unfortunately for science, the revolution of 1848 entirely arrested the farther progress of the undertaking; the house stands vacant, no instruments are provided, and worst of all, Prof. Melloni has been removed, not only from his direction in the Observatory, but also from his Professorship in the University, under the caprice of a despot who knows no law but his own will, and who has shown in this act that he was unworthy of so noble a subject.

5. *Light for Illumination obtained from the burning of Hydrogen, by M. Gillard.*

We have had an opportunity of seeing the successful application of M. Gillard's patent in the extensive silver plate works of Messrs. Christolef in Paris. It is well known that M. Gillard claims the production of a useful light and great heat from the combustion of hydrogen in contact with a coil of platinum wire—the hydrogen being produced by the decomposition of water. The apparatus employed is very simple, and consists essentially of one or more cylinders of iron arranged horizontally in a furnace similar in all respects to the usual arrangement for the production of coal gas. The retorts are charged with wood-charcoal reduced to small fragments of uniform size and heated to an intense degree. Through each of the retorts steam is conducted in a tube pierced with numerous very minute holes so disposed as to distribute the steam in an uniform and very gradual manner over the heated coal. The boiler for the production of the steam is conveniently situated in the same furnace employed for heating the retorts. Decomposition of water ensues of course, accompanied with the production of carbonic acid, (CO_2) carbonic oxyd (CO) in small quantity, of free hydrogen and a limited quantity of light carburetted hydrogen gas, (C_2H.) The mixture of these gases is conducted through a lime purifier to remove carbonic acid, and without farther washing or purification, the product is ready for use. Consisting almost wholly of hydrogen gas, the flame of its combustion is of course very feebly luminous; to obviate this difficulty, it is burned in contact with a cage or net work of platinum wire gauze surrounding an ordinary argand burner, protected by a glass chimney. This simple contrivance (so well known in the lecture-room) is perfectly successful, and the light given out from gas lamps of this construction is extremely vivid and constant.

This invention claims the following advantages in practice: 1. The gas so produced is cheaper than any other mode of artificial light, costing, as is asserted by M. Gillard and sustained by the ample experience of M. Christolef, only about $\frac{1}{16}$th the average cost of coal gas. 2. The gas has no unpleasant odor, being entirely free from the volatile hydrocarbons which are so peculiarly offensive in oil and coal gas. 3. The products of its combustion are almost solely water, so little carbonic acid resulting in the combustion that practically it may be disregarded. 4. This mode of producing gas may be applied to any existing gas works by a slight modification of the retorts, and without any essential change in other portions of the apparatus—the platinum cages being applied to the argand burners. 5. The cheapness of this mode enables us to apply it with great advantage as a fuel for cooking and for numerous purposes in the arts. For example, we saw in the establishment of M. Christolef, the soldering of silver plate accomplished in a rapid and remarkably neat manner by a powerful jet of this gas, driven by a pneumatic apparatus. Its perfect manageableness, the ease with which an intense heat is applied locally and immediately when it is wanted, coupled with advantages of employing for such a purpose so powerful a deoxydizing agent as hydrogen, render this mode

of soldering preferable to every other, and peculiarly suited for the process of autogenous soldering. 6. The nuisances resulting from the presence of large coal gas works in populous districts are entirely avoided by this mode, which is as free from objection as a steam engine. 7. The arrangements are so simple and inexpensive that every establishment where it is desired to employ light and heat, may erect its own apparatus even in the most isolated situation, all the materials employed being every where accessible.

It is understood that M. Gillard has secured his patent in the United States, and it is presumed that his method will soon be practically tested there.

We merely add that the result of M. Gillard's invention in one particular differs from the anticipation of chemists: that is, we should expect from the decomposition of water in this mode the production of carbonic oxyd CO, carbonic acid CO_2, and light carburetted hydrogen C_2H, with a limited amount of free hydrogen. The result of his experience, however, seems to establish the statements already made, as may be seen in a report of the Commissioner of the Society for the Encouragement of Industry, &c., to whom the subject was referred.

Art. XXX.—*Extracts from the Proceedings of the Twenty-first Meeting of the British Association, held at Ipswich, July 2.**

1. *From the Address of Prof.* Airy, *the Astronomer Royal, at the opening of the Meeting.*

* * * Commencing, then, with the subject which stands first in the Reports of the Association, and on which the funds of the Association have been most generously expended and its influence very energetically employed, I remark that the progress of Astronomy in the last year has been very great. The Earl of Rosse has been much engaged in experiments on the best methods of supporting and using his large mirrors. The construction adopted some time since is still retained;—namely, a system of levers distributing their pressures uniformly over eighty-one points, each pressure being transmitted through a small ball which permits to the mirror perfect freedom of slipping in its own plane, so as to take proper bearing in the chain or hoop which supports it edgeways. To Lord Rosse's critical eye the effect even of this mounting, though greatly superior to that of any preceding, is not quite perfect. In the progress of the experiments, some singular results have been obtained as to the set which a metal so hard as Lord Rosse's composition may receive from an equal pressure of very short duration. A surface of silver, I believe, has now been successfully used for the small reflector.

With regard to the character of the discoveries in nebulæ made with this instrument I cannot briefly give any very correct idea. The most remarkable is, the discovery of new instances of spirally-arranged

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* From the Athenæum of July 7 and 12, Nos. 1236, 1237.

nebulæ: but there are also some striking examples of dark holes in bright matter, dark clefts in bright rays, and resolvability of apparently nebulous matter into stars. I do not deny the importance of the last observation; but as it might be predicted beforehand that the increase in the dimensions of telescopes would lead to more extensive resolution of nebulæ, I do not hold the inference to be by any means certain that all nebulæ are resolvable. Mr. Lassell exhibited at the last meeting of the Association a plan for supporting his two-feet mirrors without flexure. This plan, slightly modified, has been adopted in use: and I am assured that the improvement in what before seemed almost perfect definition is very great.

The removal of the vexatious fiscal interferences that have been connected with the manufacture of glass, and the enterprise with which Mr. Chance as manufacturer and Mr. Simms and Mr. Ross as opticians have taken up the construction of large object-glasses, promise to lead to the most gratifying results. Already Mr. Simms has partially tested object-glasses of 13 inches aperture; and one of 16 inches is waiting not for the flint but for the crown lens. Mr. Ross, it is understood, has ground an object-glass of 2 feet aperture; but it has not been tested. The facility of procuring large object-glasses will undoubtedly lead to the construction of graduated instruments on a larger scale than before; and it is in this view that I contemplate as a matter of no small importance, the erection (this year) of the large transit-circle at the Royal Observatory at Greenwich. It is known to many members of the Association that this instrument was constructed in this town, by Messrs. Ransomes & May; and for the admirable proportions of its various parts, for the firmness of fitting of the few portions of which it is composed, and for the accuracy of the external forms of pivots, &c., it may well be considered as one of the finest specimens of engineering that has ever been produced. As an example of an excellent mechanical structure carrying a large object-glass, I think it probable that this Greenwich transit-circle may have a great influence on the construction of future instruments.

I had hoped to be able by this time to report to the Association some account of the American method of recording transits, by a puncture or dot produced by a galvanic agency whose circuit is closed by a touch of the observer's finger,—and especially on its fitness for the wants of a really active observatory; but the delays of construction have prevented me from doing so. Shortly before the last meeting of the Association, the President for the time (Dr. Robinson) transmitted to the government, on the part of the Association, a general request that a large reflecting telescope might be sent to some of the British possessions in the southern hemisphere, for the purpose of observing the southern nebulæ; and shortly after that meeting an answer was received from the Lords of the Treasury, to the effect that their Lordships entirely recognized the importance of the object, but that there appeared to be practical difficulties in the immediate execution of the design. I cannot doubt that when a more explicit plan has been formed, another representation will be accompanied with the same success which has attended every application made by the Association for aid in a carefully arranged design.

The continuation of the observations on *a* Centauri at the Cape of Good Hope has fully confirmed the result first obtained,—namely, that the parallax of that star exceeds nine-tenths of a second, or that its distance from the sun is about twenty billions of miles. So far as we have the means of judging, this star is our nearest neighbor in the sidereal spaces. The attention of foreign astronomers is still directed to the irregularities in the proper motions of stars, and the opinion seems to be gaining ground that many of them are accompanied by non-luminous companions. In our own solar system, the most remarkable discovery is that (made independently, though on different days, in America and in England) of a dusky ring interior to the well-known rings of Saturn. It now appears that it had been seen several years before; but it then attracted no attention. How such a ring is composed, and how sustained, are questions upon which perhaps the physical astronomer may long employ himself.

But the discovery for which the year will be most frequently cited is that of three additional planets, included in the same planetary space—between Mars and Jupiter—in which eleven others had been previously found. The last of these (Irene) discovered by Mr. Hind, observer in the private observatory of Mr. Bishop, forms the fourth of his list,—and makes his number the greatest that any one man has ever discovered.

Some time since, a grant was made by the British government for the perfection of the Lunar Theory and Lunar Tables on which Prof. Hansen, of Gotha, had been engaged, but whose progress was stopped by the interruption of funds in consequence of the unhappy Schleswig-Holstein war. I understand that with the aid of this grant, equally honorable to the British government and to the foreign philosopher, the work is now rapidly advancing. I have reason to believe that the theories of Uranus and Neptune are now undergoing careful revision; and I trust that one of the elements most urgently required, namely, the mass of Neptune, will be supplied from observations of Neptune's satellite made with the large telescopes to which I have alluded.

At the Edinburgh meeting, the attention of the Mathematical and Physical Section was called by M. O. Struve (there present) to the total eclipse of the sun which is to occur on the 28th day of the present month; and the General Committee appointed a committee of members of the Association to draw up suggestions for the observation of the eclipse. These suggestions have been extensively distributed both at home and abroad: and I am happy to announce one of the results. After consideration of the singular appearances observed in the eclipse of 1842, it was determined by the committee to recommend (among other things) that observing stations should be selected, if possible, in triplets: the three stations of each triplet having relation to the north boundary, the centre, and the south boundary of the shadow. The Russian government has fully adopted this suggestion; and has actually equipped six triplets, including in all eighteen stations, with observers and instruments for the observation of the eclipse. Russian officers in the Sea of Azov and the Black Sea will also observe it. Since the issue of the suggestions, the observations made last year on an eclipse visible at Honolulu in the Sandwich Islands have been received; and they make us, if possible, still more desirous that the spirit

of the suggestions should be complied with, as far as possible. There is only one subject of regret connected with this remarkable eclipse,—namely, that it will deprive us of the assistance of several astronomers who would undoubtedly have joined this meeting but for the necessity of being ready, at definite points, for the observation of the phenomena.

Among subjects related in some measure to astronomy, I may first allude to M. Foucault's experiment on the rotation of the plane of a simple pendulum's vibration; an experiment which has excited very great attention both in France and in England, as visibly proving, if proof were necessary, the rotation of the earth. It is certain that M. Foucault's theory is correct; but it is also certain that careful adjustments, or measures of defect of adjustment, are necessary to justify the deduction of any valid inference. For want of these, the experiment has sometimes failed. The Council of the Association have long regretted the very great delay which has occurred in the publication of the geodetic results of our great National Survey; and they were prepared some time since to represent strongly to the government the expediency of taking immediate steps for completing the few calculations which yet remained to be made, and for publishing the whole in a form which should be available for discussions of the figure of the earth. On communicating with the Royal Society, they learned that that body had made an urgent recommendation to the same tenor, and that in consequence, government had consented to place on the estimates a sum of money expressly for the purpose of completing and publishing the scientific portions of the survey. I have received official information that this work is now in active progress; and I cannot but remark on it as a striking instance of how much may be sometimes effected for the purposes of science by simply completing what is nearly complete. The great Swedish and Russian Arc of Meridian, from the North Cape to the Danube, is so far advanced that its completion is expected in the present year.

At the last meeting of the Association, a Committee was appointed expressly to urge on the government, what had long excited the attention of the Association, the defective state of the survey as regards Scotland. I am happy in stating that there is strong reason to hope that a large sum will in future be appropriated to the Scotch Survey.

The next subject to which the influence of the Association was energetically directed is, Terrestrial Magnetism; with which Meteorology has usually been associated. Although the active employment of several of the Colonial Magnetic and Meteorological Observatories has terminated, (those only of Toronto, Hobartown, Cape of Good Hope, Madras and Bombay being retained, and only in partial activity,) the work connected with them has not yet ceased. Much has yet to be done in the printing and discussion of the observations:—a work going on under the care of Col. Sabine. In tacit association with the representative of the government, the agents of the Association are employed at the Kew Observatory, under the superintendence of Mr. Ronalds, in devising or examining new instruments. The Daguerrotype method of self-registration (which is perhaps liable to this objection, that the original records are destroyed) has been extended to the vertical-force instrument. Apparatus has been arranged for the graduation of original

thermometers—a subject to which the attention of M. Regnault and Mr. Sheepshanks had been advantageously directed. And, with the assistance of a portion of the sum placed by the Government at the disposal of the Royal Society (to which I shall hereafter refer), it is hoped by the officers of the Association that the Kew Observatory will be made really efficient for the testing of new instruments. Dr. Robinson's very instructive account of his new anemometer has lately been received: this instrument, however, has not yet been used in many places. Among the immediate deductions from magnetic observations, I may specially mention Col. Sabine's remarks on the periodical laws discoverable in disturbances apparently of the most irregular kind, and M. Kämtz's corrections of the Gaussian constants.

Among the more distant results, there is nothing comparable to the experiments into the magnetic properties of oxygen, and especially into the variation of its power, made by Faraday and Becquerel,—and the application of these results to the explanation of the phenomena, in almost all their varied forms, of so-called terrestrial magnetism. It is to the former of these philosophers that this great step in the explanation of obscure natural phenomena by inference from delicate experiments, is mainly or entirely due. Much, of course, remains to be done, before we can pronounce accurately how far this principle enables us to account, without any reference to any other cause, for the regular changes, as well as for the capricious disturbances, in ordinary magnetism. I ought not to omit stating that such general explanation had long ago been suggested in a very remarkable paper by Mr. Christie; but the experiments actually applying to the magnetic properties of oxygen were unknown, and perhaps impossible, at that time. In the science of abstract magnetism, the distinction between paramagnetic and diamagnetic substances has been thoroughly worked out by Mr. Faraday, and is now received as one of the most remarkable laws of nature. In the related subject of Galvanism, although much of detailed law has been established by the labors of the same great man and of others, it is difficult to fix upon any new law of general character. Experiments made in America seem to establish that the velocity of the galvanic current in iron wires of a certain size does not exceed fifteen or eighteen thousand miles per second: a much greater speed, however, is inferred by M. Fizeau, from the same experiments. The first part of an elaborate mathematical theory of Magnetism, by Prof. Thomson, has been published.

In Meteorology, some striking facts have been collected and arranged by Col. Sykes in regard to India, by Messrs. Schlagentweit in regard to the Alps, and by M. Plantamour in the comparison of observations at Geneva and the Great St. Bernard; and some very unexpected facts have been extracted by M. Arago from the observations on a balloon ascent at Paris. The systematic collection of observations of luminous meteors, in Reports by Prof. Powell, printed in the volumes of the Association for the last two years, can scarcely fail to lead to some discovery of the origin and nature of those mysterious bodies. An extensive series of meteorological observations had been made at the Ordnance Survey Office at Mountjoy, near Dublin, and the Association some years since recommended to the government the early printing

of those observations. I have the gratification of stating that considerable progress has now been made in preparing them for the press.

At the last meeting of the Association, a project was laid before the General Committee, by M. Kupffer, for the formation of a Meteorological Confederation, to be extended over the whole of Europe. A very extensive organization, covering almost the whole Russian Empire, has already been created. The Council to whom the project was referred, after very careful consideration, deemed it inexpedient to join in the proposed Confederation. They were deterred by various practical difficulties, of which some may perhaps always exist, while others are felt with unusual force at the present time. It was with extreme unwillingness that the Council adopted this resolution, and with the full hope that at some future time a confederation similar to that proposed by M. Kupffer may be firmly established.

Under the auspices of the Board of Ordnance, the officers of the corps of Royal Engineers are making arrangements for the establishment of a uniform system of meteorological observations, of a simple kind, at the principal engineers' stations in every part of the earth. If with these could be combined occasional trustworthy observations at sea, we should probably have the most complete system of Terrestrial Meteorology that we can hope to obtain.

Among the systematic observations of less ostentatious character, I cannot omit referring to the daily report of the state of the wind at 9 o'clock every morning, which is supplied by the superintendents of railway stations, over a great portion of the British isles, and printed in the *Daily News* newspaper.

A new Meteorological Society has been formed, which (I believe) is at least in this respect, superior to those which have preceded it—that the instruments used by the various amateur members are strictly comparable: great attention having been given to the adjustments of the instruments, by the Secretary, Mr. Glaisher.

In Optics, two or three investigations of rather important character have, since the last meeting of the Association, attracted public attention. Experimental measures of the velocity of light in air and in water, made by MM. Foucault, Fizeau and Brequet, with apparatus nearly similar to that employed long ago for analogous purposes by Mr. Wheatstone, appear to leave no doubt that the velocity in water is less than that in air,—a most important, and indeed critical, result in regard to theories of light. A remarkable investigation by Prof. Stokes, when compared with experiment, seems to establish that the vibrations constituting polarized light are, as for other reasons was supposed by Fresnel, perpendicular to what is usually called the plane of polarization. Some optical theories which admitted formerly of very imperfect mathematical treatment have been brought under the dominion of analysis by Prof. Stokes's powerful methods of investigation. A curious series of experiments on diffraction has been published by Lord Brougham; but they have at present no bearing on theory, as the theoretical calculations with which they must be confronted appear to be too difficult or too complicated for the present state of pure mathematics. The experiments of Jamin regarding the reflection of polarized light under peculiar circumstances appear to give support to the

theoretical calculations of Cauchy, founded on a molecular hypothesis applied to the undulatory theory. And lastly, some curious experiments by Mason, Jamin, Prevostaye, and Desains, appear to show more fully, what had partially been shown by Prof. Forbes, that radiant heat admits of polarization in all respects similar to that of light. * * *

2. *On Diamagnetism and Magne-Crystallic Action;* by Dr. J. Tyndall.

One of the most important inquiries which at the present day occupy the attention of the student of physical science, is the relation which subsists between magnetism and diamagnetism. Are the laws which govern both forces identical? Will the mathematical expression of the attraction in the one case be converted into that of the repulsion in the other case, by a change of sign from positive to negative? To this question Plücker replies "No." His experiments have led him to the conclusion, that when the power of a magnet which operates upon a body composed of magnetic and diamagnetic constituents is increased, the diamagnetism of the compound mass increases in a much quicker ratio than the magnetism; that in consequence of this an indifferent body is a physical impossibility; for a body in which the respective forces might be exactly equal and apposite when excited by a magnet of a certain strength would, upon lowering the power of the magnet below this standard, be attracted,—and by increasing the power of the magnet beyond this standard, be repelled.

During a previous investigation, the author of the present memoir had repeated opportunities of observing phenomena exactly similar to some of those which form the premises of Plücker's conclusion; and a close study of the subject convinced him that to account for these phenomena the hypothesis of two conflicting forces in the same compound mass, the one or the other of which predominates according as the power of the magnet is increased or diminished, was by no means necessary. To fit himself for the investigation of this question, he commenced an inquiry last November into electro-magnetic attractions; one of the results of this inquiry was, that a sphere of soft iron separated from the end of a straight electro-magnet by a small fixed distance, was attracted by the latter with a force exactly proportional to the square of the exciting current. Now, this attraction is in each case the product of two factors, one of which expresses the magnetism of the magnet, and the other the magnetism of the ball; and it is easy to see, that while the attraction increases as the square of the current, the magnetism of the ball increases in the simple ratio of the current itself. Our way to a comparison of magnetic attraction and diamagnetic repulsion is now clear. We know the law according to which the magnetism of the iron ball increases, and we have only to inquire whether the diamagnetism of the bismuth ball follows the same law. The apparatus used in the former case proved, however, to be totally unfit for the measurement of diamagnetic force,—the feebleness of the latter rendered a much more delicate mode of measurement necessary. The torsion balance was the instrument finally resorted to by the author. A loop of paper was attached to one end of a fine silver wire, and in the loop rested a little beam of light wood. At the ends of the

beam, which was six inches long, two spoon-shaped hollows were worked out, in each of which a ball of the substance to be experimented with might be placed. Two cones of soft iron, surrounded by helices of copper wire, were placed at right angles to the beam when horizontally suspended, the one cone facing the ball at one end, and the other cone facing the ball at the other end. The silver wire was carried upward through a tube three feet in length, and was connected at the top with a torsion head. When the cones were excited, by sending an electric current through the surrounding helices the balls were repelled. The index of the torsion head was then gently turned against the repulsion until the balls were brought within $\frac{1}{12}$th of an inch of the ends of the respective cones. The torsion necessary to effect this is evidently the expression of the repulsive force exerted at this particular distance. The strength of the exciting current was measured by a galvanometer of tangents, and it was regulated by means of a rheostat. The cones were excited by currents which varied from 10° to 57°, and the corresponding repulsions were determined. Spheres of the following diamagnetic substances were used:—1. Bismuth of commerce; 2. Chemically pure bismuth obtained by dissolving the material of commerce in nitric acid, precipitating it with distilled water, washing the precipitate for six days successively, and reducing it by means of black flux; 3. Sulphur of commerce; 4. Spheres from a crystal of native sulphur obtained in Sicily; 5. Calcareous spar from Clitheroe [?]; 6. Calcareous spar from Andreasberg, in the Hartz mountains, Germany. In all these cases the diamagnetism of the spheres followed precisely the same law as the magnetism of the sphere of soft iron:—it was exactly proportional to the exciting current.

These results cannot be reconciled with the statement that diamagnetism increases with the increasing power of the magnet in a much quicker ratio than magnetism. The experiments of Plücker might be accounted for in many ways, but such explanations, being necessarily conjectural, may be omitted here. It is known that crystalline bodies suspended between poles of a magnet exhibit phenomena which are absent in the case of amorphous bodies. A certain line through the crystal will take up a certain determinate position; and if this line be forcibly moved away from this position, when the force is removed it will return to it. Thus, a crystal of pure carbonate of lime suspended by a silk fibre between the poles with its optic axis horizontal, will always turn until the optic axis is perpendicular to the line joining the poles, in which position it will come to rest. This fact was discovered by Plücker, who referred it to the operation of a new force which was entirely independent of the magnetism or diamagnetism of the mass of the crystal. In an investigation conducted by the author in companionship with Prof. Knoblauch, of Marburg, this hypothesis of a new force is rejected; and it is there shown that the position of the optic axis, so far from being independent of the magnetism and diamagnetism of the mass, is entirely changed if a magnetic constituent be substituted for a diamagnetic. Thus, for instance, carbonate of iron differs from carbonate of lime only in the fact that in the former case an atom of iron is substituted for an atom of calcium. The crystalline form in both cases is identical, the optic axis of carbonate of iron sets

nevertheless from pole to pole with an energy far surpassing that with which the optic axis of carbonate of lime sets perpendicular to the line joining the poles. But why is it that one direction in the crystal takes up a particular position? The torsion balance gives a prompt answer to this question. A sphere of calcareous spar was placed upon each of the spoon-shaped hollows of the beam, the direction of the optic axis through each sphere being carefully marked. The spheres were first placed so that the optic axes were parallel to the axes of the soft-iron cones,—and secondly, perpendicular to the same. The repulsion in the former case was to the repulsion in the latter in the ratio of 53 to 48. If a bismuth crystal be suspended between two poles, the plane of most eminent cleavage will always set perpendicular to the line joining the poles, that is, equatorial. A cube formed from this crystal was placed on each end of the little beam; first, so that the planes of principal cleavage were parallel to the axes of the cones; and secondly, perpendicular to them. The repulsion in the former case was to the repulsion in the latter, in the ratio of 53 to 38. The diamagnetic mass in both these cases is repelled with a greater force in one direction than in any other direction. When the crystal is suspended between two poles, the line which marks the direction of maximum repulsion recedes as far as possible from the poles, and hence sets equatorial.

A result the exact antithesis of the above was observed with magnetic crystals. A cube of sulphate of iron was attracted in one direction by a force of 43, and in another direction by a force of 36·3. A sphere of carbonate of iron was attracted in the direction of the optic axis by a force of 43, and in a direction perpendicular thereto by a force of 30·5. When these crystals are suspended between two poles, these lines of chief attraction approach the poles, and finally set axial. Thus we see that the peculiar phenomena exhibited by crystals in the magnetic field are to be referred to a modification of magnetism or diamagnetism brought about by the peculiar structure of the crystal. Let us endeavor to penetrate this mystery of structure. Our next inquiry is—what direction is that which is chosen by the respective forces for the manifestation of their greatest energy? To this question the author imagines that a full and intelligible reply is returned by experiment. If the arrangement of the component particles of any body be such as to present different degrees of proximity in different directions, then the line of closest proximity (other circumstances being equal) will be that of strongest attraction in magnetic bodies, and of strongest repulsion in diamagnetic bodies. The torsion balance furnishes us with the means of submitting this conclusion to a direct test. A quantity of bismuth was ground to dust in an agate mortar, gum-water was added, and the mass was kneaded into a stiff paste. This was placed between two glasses and pressed together. From the mass when dried two cubes were taken, the line of compression being perpendicular to two of the faces of each cube and parallel to the other four. Suspended by a silk fibre in the magnetic field, upon closing the circuit the line of compression turned strongly into the equatorial position, exactly as the plane of most eminent cleavage in the case of the crystal. The cubes were placed one upon each end of the torsion balance, first with the line of compression parallel to the axis of the cones, and secondly per-

pendicular thereto; the repulsion in the former case was to the repulsion in the latter in the ratio of 53 : 30. A greater differential action was thus exhibited in the case of the model than in the case of the crystal. A pair of cubes constructed in the same manner from powdered carbonate of iron, exhibited an analagous predominance of attraction in the line of compression.

Against this mode of experiment an objection was urged, during the meeting of the British Association at Edinburgh last year, by Prof. Wm. Thomson, of Glasgow. "You have," he said, "reduced the mass to powder, but you have not thereby destroyed the crystalline form; your powder is a collection of smaller crystals,—and the pressing of the mass together gives rise to a predominence of axes in a certain direction, so that the repulsion and attraction of the line of compression, which you refer to closeness of aggregation, is after all a product of crystalline action. Besides, we know that compressed isinglass exhibits the same optical phenomena as crystals, and you are unable to prove that the action is not due to a *quasi* crystalline structure induced in the gum by compression." The following experiment will set this point at rest. It will not only show the influence of compression apart from the mere arrangement of the axes or from the influence of the gum, for none will be used; but it will also demonstrate the total nullity of this presumed axial force where opposed to the influence of compression. To this experiment I was conducted by the following accident. The investigation was conducted in Berlin, and the great electro-magnet of the University was beside me at the time. Some notion of the power of this magnet may be gathered from the fact, that the copper helices alone which surrounded the iron pillars which composed the magnet, weighed 243 pounds. On the top of the pillars two movable masses of soft iron were placed, each weighing about 25 pounds, and between these the substance to be examined was suspended. Before I had thoroughly made the acquaintance of the instrument, I hung a fine cube of bismuth crystal between these movable poles; on closing the circuit the planes of most eminent cleavage receded to the equator. Scarcely, however, was this attained when I observed the poles moving towards each other, and before I could break the circuit, they had rushed together and clenched their iron jaws upon the crystal. The latter was reduced by the pressure to about three-fourths of its primitive thickness, and it immediately occurred to me that if the theory of proximity were true it ought to tell here. The pressure brought the particles of the crystal in the line of compression more closely together, and hence a modification, if not an entire reversion, of the former action might be anticipated. Having liberated the crystal, I boiled it in hydrochloric acid, so as to remove any impurity it might have contracted by contact with the iron. It was again suspended between the poles, and completely verified the foregoing anticipation. The line of compression, that is, the magnecrystallic axis of the crystal, which formerly set from pole to pole, set now equatorial. The experiment was then repeated with a common vice; various pieces of bismuth protected by plates of copper were placed within its jaws, and there pressed to the thickness of a shilling. The plates thus obtained when suspended from their edges in the magnetic field, exhibited one

unvarying result:—the line of compression stood always equatorial, and it was a matter of perfect indifference whether this line was the magnecrystallic axis or not. In these cases no gum was used, and not only was a predominance of axes present, but they all worked together; they were further assisted by the great mechanical advantage offered by such plates to diamagnetic repulsion; the line of compression nevertheless triumphed over all and determined the position of the crystal.

The author concludes his paper as follows: "Whoever denies the influence of proximity will have to answer the following questions:—How is it possible that a greater differential action can be exhibited by a cube of bismuth dough, than by the crystal itself? What is it which causes the magnecrystallic axis to forsake its usual position, and to set equatorial when the crystal is compressed in the direction of that axis? He must further assume a crystalline structure on the part of wax, flour, shale, and the pith of fresh rolls; for in all these substances the line of compression determines the position of the mass in the magnetic field."

At the conclusion of the paper, Prof. Faraday rose, and spoke at some length on the valuable contribution to science which had been brought before them by Dr. Tyndall. It afforded him great gratification that there was one at least among us who had followed up this important subject so perseveringly. The beautiful laws established by Dr. Tyndall proved the identity of magnetism and diamagnetism in one important particular,—a result which he always anticipated; and if the crystalline action could be explained by what might be called the gross mechanical experiments brought before them, the discovery was one of the utmost consequence. It gave him pleasure to be able to propose a question to one who had worked so long at the foundations of this matter. Many philosophers had affirmed that it was possible to convert attraction into repulsion, and *vice versâ*, by merely varying the magnetic power: this was contrary to his own experience, and he wished to ask Dr. Tyndall whether he had ever met a case of the kind.—Dr. Tyndall stated in reply that he had diligently sought for such a case, but had never succeeded in finding it.

Prof. Faraday felt prepared to admit that some of Dr. Tyndall's results seemed to promise an explanation of Plücker's perplexing results and conclusions; but for his own part he was anxious to keep his mind free from bias, to get well-established facts, and to free them as much as possible from all circumstances which could mark, or disguise, or mislead in the interpretation of them,—and such being his fixed determination and settled habit, he was rather at a loss to remember to what portion of his publications on the subject Dr. Tyndall referred when he supposed him to have considered the facts now brought forward as improbable.

3. *Report of the Kew Magnetographs;* by Col. Sabine.

The author said that at the request of the Council he was about to give the Section a brief account of the experimental trial now making at the Kew Observatory of Mr. Ronald's instruments for the self-registry of the variations of terrestrial magnetism by means of photography.

These instruments had been described at former meetings: but it was deemed advisable to subject them to a practical trial to test their efficiency as a means of recording the magnetic phenomena in any part of the world where science might require them to be better known. Before, however, it could be known in what degree they might be useful either as auxiliary or as superseding altogether the method of observation previously in use, it was necessary that three instruments should be provided,—one for the variations of declination and two for those of the horizontal and vertical components of the forces. The limited funds at the disposal of the Association for the purposes of the Kew Observatory barely enabled them to complete two of these instruments between the years 1846 and 1850; and the third must have yet been waited for had not the President and Council of the Royal Society, seeing the importance of the object, appropriated a portion of the sum placed at their disposal by government to this purpose. The three instruments being now completed, Mr. Ronalds proposed to the Council that a six months' trial should be made of the working of these instruments precisely as they would be in an observatory, and that every item of expense incurred in that practical trial should be carefully noted and faithfully reported. The Council of the Royal Society having approved of this trial, a grant was made from the donation fund of 100*l*. The six months' trial commenced in April last, and when it shall be completed a full report will be made to the Council of the Royal Society. In the mean time it was thought that a brief report of the progress so far made would be acceptable.

In Mr. Ronald's instruments the magnetic variations are recorded either on silvered plates or on prepared paper. The silvered plates have the advantage of greater sensibility, and in consequence require a less time of exposure to the light,—so that movements of a more rapid character or more transient duration may be recorded by them; also, they produce more sharply defined traces; they are free from the defects arising from inequalities of surface, and the stretching and shrinking of the paper by being wetted and dried. The paper on the contrary, has the advantage that the original tracings and records of the variations can be preserved,—a matter impossible with the plates, except in some very rare and interesting cases. In coming to a just conclusion in this comparative estimate of the merits of each method, the practical object to be attained should be kept in view. No doubt a mere inspection of the actual tracings as shown either on the plates or the paper possesses an interest both to the uninstructed and to those more familiar with the phenomena; and amidst the great variety of them some may have light thrown on them by a close inspection and consideration of the trace itself. But as in astronomy the great advance of the science has followed the combination of measuring apparatus with optical power,—so in terrestrial magnetism the various periodical and other causes which in their joint action produce the variations, require that the traces of them should undergo tabulation as an indispensable preliminary to their practical application. In Mr. Ronald's plan the tracings when taken on the silvered plates are tabulated with tolerable rapidity, and are then copied by hand with a graver's tool on sheets of transparent gelatine paper,—an operation requiring about a

quarter of an hour to copy the twenty-four hours work of the instrument. Both sides of the trace being marked, this can be done after a little practice with very considerable accuracy. The copies thus made are arranged in a journal and preserved. The original plate, except in rare cases, is then cleared off for new work. The gelatine paper is transparent, durable, and bears handling so well that impressions can be freely taken on paper with printers' ink and a small press; which on days of unusual disturbances can be sent by post to other observatories. The measuring and taking the means and tabulating the tracings are a far more serious operation as far as time is concerned; but under the able management of Mr. Welch, to whom Mr. Ronalds has intrusted this department of the experimental trial, this can be all accomplished for the twenty-four hours' work in about three-quarters of an hour,—and thus the great advantage of producing a continuous record is obtained. The plates as used at Kew are twelve inches long, and every twelve hours are reversed, thus giving a second tracing on each plate. The breadth there used is three inches, which is found to be ample. But in parts of the globe where great disturbances prevail and where at the same time great precision is required in the variations of small amount, a larger field than three inches may be desirable and may be given. It has been found by the concurrent experience of several that the tracings on the plates can be read off with full confidence to the 500th of an inch. This gives in the three-inch plate, 1,500 distinctly recognizable points. Taking the declinometer as an easily understood example, a single division of the scale is made equal to six seconds: the range of the scale will therefore extend to $6 \times 1{,}500 = 9{,}000$ seconds, or $2^\circ\ 30'$.

Great stability and freedom from shaking of Mr. Ronalds's apparatus is obtained by binding together all parts which have reference to each other by marble or metal, and only using wood for outside casing. Another great advantage is, the constancy of the zero line, which is insured by mechanical contrivance. The zero line has thus a permanent magnetic value which remains unchanged as well from day to day as at all times of the same day. The time of the exposure to the light by which each part of the tracing is at present taken is one and a half minutes. It is, however, probable that by improvements in photographic preparations, the trace may hereafter be taken by exposure of much less duration; also that the length of the magnets, now twelve and fifteen inches, may be greatly reduced. Both these improvements appear to be required if we desire that the trace should individualize perturbations succeeding each other with great rapidity.

The Astronomer Royal said that, while he admitted that at Kew the photographic method of registering these or similar observations was first introduced successfully, and that the methods there used were essentially the same as those of Mr. Brook, which had been adopted at the Royal Observatory, Greenwich, he could not help thinking that there was one important distinction. In Mr. Brook's method, a sheet of photographic paper wrapped on a cylinder received and recorded the working of the instrument; and these original records, carefully dated, were kept. Where silver plates were used it was of course impossible to preserve the original records; after the tracings were

transferred by hand to the gelatine paper the silver plates had to be cleaned off, otherwise it is obvious they would soon multiply to a number too expensive and cumbrous to be used. Now, he had strong doubts that any person could transfer by hand all the minute fluctuations of the instrument; he did not now speak of the great magnetic storms, the indications of which were constant and universal, but he alluded to those sudden, slight, but now important agitations which the instrument seemed to undergo after working on each side of its mean position with great steadiness. And yet, from the recent discovery of Prof. Faraday as to the varying relations of oxygen to magnetism by alterations of the temperature, it became highly probable that these same slight waverings of the magnetometer would be found to have an interest attached to them hitherto altogether unsuspected.

4. *On our Ignorance of the general course of the Tides;* by Dr. Whewell.

In 1833 Dr. Whewell published in the *Philosophical Transactions* an essay towards a first approximation to a map of co-tidal lines; in which he attempted, from the data then accessible, to draw lines expressing the course of the tide wave all over the ocean. So far as the coasts are concerned, this mode of expressing the course of tides is still held to be the best; but our materials, which were scanty at the former period, are very incomplete even yet, with the exception of the coasts of Europe and the east coast of North America, the east coast of Australia, and the east coast of New Zealand. In order to trace the course of the tides on any coast, we ought to know the points of divergence and of convergence of the tidal wave. We do not know these points on the west coast of Africa, or on the east coast of South America; and consequently we do not know the course of the tides of the Atlantic, nor do we know the relation of the tides of the Atlantic islands, (the Ferroes, Azores, Bermudas, Cape Verde Islands, &c.,) to the tides of the coasts. It was urged that the course of the tides in this and other oceans could not come to be known except by an expedition, consisting of one or two small vessels, which should have for its primary and governing object the obtaining a connected knowledge of the tides of the coasts of the Atlantic, in the first place, and of those of other oceans afterwards.

The Astronomer Royal said that the inquiries to which Dr. Whewell had now directed their attention had an object definite, intelligible, and most important, whether we considered it practically in its bearing on commerce and our navy, or as an object of pure science, in furnishing the data requisite for advancing our knowledge on this interesting yet intricate branch. In such a case he found it to be always a most important matter to make a beginning, however humble, and from his own experience he could assure Dr. Whewell that he felt convinced if a proper application were made to the government to observe the tides carefully in the manner pointed out by Dr. Whewell in some limited locality,—say in the Atlantic Ocean,—such an application would meet with the attention which it so well deserved, and which he at all times found the government cheerfully to bestow on such matters. He had not the least objection, should such an application be deemed proper

by the Committee of Recommendations, to join Dr. Whewell or any Committee which should be named in pressing such an object on the attention of Her Majesty's government.

Capt. FitzRoy, R.N., said that as Dr. Whewell had done him the honor of alluding to his exertions and opinions on this interesting, and to every sailor important, branch of science, he would beg leave to make a few remarks. In the first place, he must bear his testimony to the accuracy of the statement of the learned gentleman who had brought the subject before them as to the extreme intricacy and puzzling character of the general phenomena, and our deplorable ignorance of extensive fields of research in it. It was known to most of those whom he addressed, that Sir John Herschel in his very delightful work estimated the average height of the rise of the tide over the whole surface of the earth to be five feet; and from all the attention he could bestow on the subject and the best estimate he could form, guided by long continued and very widely extended actual observations of the tides, he believed this to be a very correct opinion. And yet most who heard him were aware how widely in several localities this average was departed from. Several localities could be pointed out where the total rise of the tide was to be spoken of as inches; while in other, and frequently not very distant, places, the rise was six, seven, eight, or more fathoms.

Capt. FitzRoy then stated, that along the entire western coast of South America the tides could scarcely be said to be earlier or later at one place than at another,—as for hundreds of miles, indeed nearly as far as Panama, they might be said to occur at the same time, though they only rose four or five feet. At the Straits of Magellan they were very remarkable; on the west side they rose but a few feet, say four or five, but on the eastern side they rose to the enormous height of seven or eight fathoms, and this within a few miles the one place of the other. He considered this to be accounted for thus.—On the western side they partook of the general character of the tides of the Pacific along the coast,—but on the east, the great tide from the Atlantic setting in through the Straits and meeting the tide coming from the west, the waters became heaped up to the extraordinary height he had stated. He then proceeded to mention several other peculiarities and anomalies of the tides in the Great Pacific Ocean:—and said that a general review of them had led him to throw out the conjecture alluded to by Dr. Whewell, that in this great basin the tides seemed to be at one time urged forward by the luminary as it passed along over them towards the west, and then afterwards seemed to surge back again towards the east; and in this motion to an fro the waters of this great basin might be conceived as a whole to partake; while yet the motion of no one part need move more than a very few feet from its place.

5. *Observations on Atomic Volumes and Atomic Weights, with considerations on the probability that certain bodies now considered as elementary may be decomposed;* by Prof. DUMAS.

Prof. Dumas alluded to the solubility of some substances and the insolubility of others, giving many instances of the difference of this quality in regard to solution in water, sulphuric and strong acids, and

referred to Berthollet's views and experiments on this subject. The measure or volume of bodies he thought might be represented with as much facility as the weight: thus, for example, magnesia and sulphuric acid may have their volumes numerically expressed before and after combination, and also graphically by lines. Magnesia with sulphuric acid showed a certain degree of condensation, lime a greater condensation, and barytes the greatest condensation; and these he could represent and reason on as well by lines of different lengths as by figures or by words. The degree of condensation (however expressed) had also relation to the quality or degree of solubility. Thus, sulphate of magnesia was very soluble, sulphate of lime but little soluble, and the greatly condensed sulphate of baryta was insoluble. He then pursued the analogy with the chlorids, comparing the chlorid of sodium with the extreme case of the chlorid of silver.

After graphically expressing the solubility of bases with sulphuric acid by lines, he proceeded to show that the relative volumes of the elements chlorine, bromine, and iodine could be perfectly represented by lines equal in length. Prof. Dumas said that when a number of metals are represented by lines, at first they seem in confusion, and it would appear like an impossibility to arrange them in a system of lines to permit their relations to appear; but when considered in relation to the substitution of one property for another, or of the substitution of one substance for another in groups, then their arrangement became easy. And here we may remark, that Prof. Dumas had not previously prepared diagrams or tables, but covered a large black board with lines, figures, and formulæ, to follow his train of reasoning,—and symbols, volumes, and names were rapidly produced and as rapidly effaced to illustrate the Professor's views of the laws of the substitution of one body for another in a compound. Prof. Dumas gave many examples of groups of other bodies, such as the alkalies, earths, &c., arranged in the order of their affinities. He called attention in the Triad groups, to the intermediate body having most of its qualities intermediate with the properties of the extremes, and also that the atomic or combining number was also of the middle term, exactly half of the extremes added together; thus, sulphur 16, selenium 40, and tellurium 64. Half of the extremes give 40, the number for the middle term. Chlorine 35, bromine 80, and iodine 125. Or the alkalies, lithia, soda, and potassa, or earths, lime, strontia, and baryta, afford, with many others, examples of this coincidence; hence the suggestion, that in a series of bodies, if the extremes were known by some law, intermediate bodies might be discovered; and in the spirit of these remarks, if bodies are to be transformed or decomposed into others, the suggestion of suspicion is thrown upon the possibility of the intermediate body being composed of the extremes of the series, and transmutable changes thus hoped for.

Prof. Dumas then showed that in the metals similar properties are found to those of non-metallic bodies; alluding to the possibility that metals that were similar in their relations, and which may be substituted one for the other in certain compounds, might also be found *transmutable*, the one into the other.

He then took up the inorganic bodies where substitutions took place which he stated much resembled the metals. After discussing groups

in triads, Prof. Dumas alluded to the ideas of the ancients of the transmutation of metals and their desire to change lead into silver and mercury into gold; but these metals do not appear to have the requisite similar relations to render these changes possible. He then passed to the changes of other bodies,—such as the transmutation of diamonds into black lead under the voltaic arc.

After elaborate reasoning and offering many analogies from the stores of chemical analysis, Prof. Dumas expressed the idea that the law of the substitution of one body for another in groups of compounds might lead to the transformation of one group into another at will; and we should endeavor to devise means to divide the molecules of one body of one of these groups into two parts, and also of a third body, and then unite them, and probably the intermediate body might be the result. In this way, if bodies of similar properties and often associated together were transmutable, one into the other, then by changes, portions of one might often, if not always, be associated with the other. Thus, in nature when chlorine occurred, iodine and bromine might also be found, and always would be if they were transmutable the one into the other. Cobalt is thus mysteriously associated with nickel, iron with manganese, sulphur with selenium, &c. In the arts during operations when certain radicles were produced, analogous ones were found constantly to be associated. In the distillation of brandy, oil of wine is always an associated result.

Dr. Faraday expressed his hope that Prof. Dumas was setting chemists in the right path; and although conversationally acquainted with the subject, yet he had been by no means prepared for the multitude of analogies pointed out.

Mr. Grove spoke of the importance of the view; as, by knowing the extreme compounds, it might serve as a guide in experiments and as a check to the results. He adverted to the allotropic condition of substances when their principal characters were changed, but their chemical qualities were unaltered; thus, carbon in the state of a diamond had a change of property so complete that it had one of the properties of metals given or transferred to it by its conducting power for electricity under these conditions, and its other forms were states resistant to electric passage. He thought this fact of certain bodies having two sets of physical properties with greatly differing character might, with this law of the substitution of one set of chemical qualities for another in a compound group, give the hope of the great realization of some of the ideas embodied in the views of the possible transformation of one body at the will so as to possess the properties of others.

Prof. Williamson, Dr. Anderson, and Dr. Gladstone remarked on these analogies,—and referred to the groups of bodies of similar characters, but whose history was difficult or inexplicable. Thus, the metals of the platina group of bodies, the red states of phosphorus and of sulphur, the carrying of certain of these properties into the sulphurets of phosphorus, and the unsatisfactory history of bodies like the phosphates, might be rendered clear in future researches by the ideas resulting from numerous examples of the triad groups alluded to by Prof. Dumas.

6. *On a Copying Electric Telegraph;* by Mr. F. C. Bakewell.

In the method adopted for transmitting copies of writing, the letters to be transmitted are written on tin-foil with varnish, so as to present a conducting and a non-conducting surface. The foil is placed on the cylinder of the transmitting instrument, and a metal style in connection with a voltaic battery presses on the surface of the cylinder as it revolves. By this means the electric current is continually broken when the style is resting on the varnish, and as the style is made to traverse by an endless screw from one end of the cylinder to the other, it passes necessarily over all the lines of the writing, and about eight times over each line.

The receiving instrument is similar to the transmitting one, and on the cylinder of that instrument, paper moistened with a solution of prussiate of potash in diluted muriatic acid is placed; the metal style on that instrument being a piece of steel wire. When the electric current from the positive pole of the voltaic battery passes through the steel point to the paper, a blue mark is made by the production of Prussian blue,—and when the cylinder is in motion, the effect is to draw a series of spiral lines on the paper; but as the lines are broken whenever the varnish writing on the transmitting cylinder interposes, the forms of the letters are transferred from one instrument to the other,—the writing appearing of a pale color on a ground of blue lines drawn closely together. To produce this effect, it is requisite that both instruments should rotate exactly together, and this synchronous movement is attained by means of an electro-magnet,—one instrument being made to regulate the other by retarding its motion at regular intervals.

The regulation of the instrument is also facilitated by a guide-line, consisting of a strip of paper placed at right angles to the writing, by which means the person in charge of the receiving instrument can ascertain how much the speeds of the two instruments differ, and by the addition or subtraction of weight can bring the gaps formed by the strip of paper to fall exactly under each other,—which indicates that the two cylinders are revolving at the same rate. It was stated, in answer to questions by members present, that two hundred letters per minute might be copied by the instruments exhibited, and that five hundred in a minute are attainable. To illustrate the facility which this means of telegraphic communication affords for transmitting secret messages, an apparently blank piece of paper was produced, on which a message had been impressed invisibly before the meeting of the Section, and by brushing it over with a solution of prussiate of potash the writing became instantly legible.

(*To be continued.*)

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Crystalline form of the Rhombohedral Metals*, (Berichte der Berl. Akad.)—Prof. G. Rose, in continuation of his previous investigations, has examined an artificial crystal of Tellurium obtained by Mitscherlich. The form was a regular six-sided prism terminated by rhombohedral faces. The angle of the rhombohedron at the terminal edges was found to be 71° 51′. This rhombohedron is therefore a secondary to the primary rhombohedron. Prof. Rose also reckons among the rhombohedral metals the *Tetradymite* (Tellurwismuth) from Schemnitz. It affords the two rhombohedrons 81° 2′ and 66° 40′ according to Haidinger, the former being that, parallel to whose faces, composition occurs and twins are formed. Prof. Rose is therefore inclined to consider this mineral as a joint crystallization of the three constituents, bismuth, tellurium and sulphur, rather than a chemical compound. *Zinc* is also included among the rhombohedral metals. Nöggerath has observed it in hexagonal prisms and this is confirmed by Rose. The latter found for the inclination of the base on three adjacent planes replacing the basal edges respectively 110° 35′—110° 40′, 110° 31′—110° 42′, and 111° 45′—111° 50′. The discrepancy is considered not more than was to be expected from the character of the crystal, and the prism is taken to be regular hexagonal. On breaking the mass, a perfect cleavage parallel to the base of the prism was often observed, besides another cleavage less perfect. The observation of Laurent that zinc crystallizes in rhombic prisms is supposed to be an error. The statement of Nickles that it also crystallizes in monometric or tesseral forms, is not improbable since zinc has many relations to the tesseral metals. The fact shows that zinc is dimorphous.

2. *On the Equivalent of Magnesium;* by MM. R. F. Marchand and Th. Scheerer, (Journ. f. prakt. Chem., vol. l, heft 8; Phil. Mag. Feb., 1851, p. 170.)—The uncertainty which still exists as to the true chemical equivalent of magnesium, notwithstanding the numerous experiments on the subject, induced the authors to undertake fresh researches to settle the question.

The process which these chemists adopted to determine this point, consists in ascertaining the quantity of carbonic acid contained in a given quantity of native carbonate of magnesia. The mineral which principally served for these experiments is the magnesite of Frankenstein, of which very pure specimens were obtained. The numerous experiments which the authors performed show that the choice of the mineral is in nowise indifferent. When magnesite contains considerable quantities of silica, carbonate of iron, alumina, and especially water, which it is almost impossible to expel by drying without simultaneously disengaging small quantities of carbonic acid, it is unfit for the purpose of analysis.

The magnesite of Frankenstein contains only 0·05 per cent. of foreign matter, of which an account is taken in the calculations. A certain quantity of this mineral, well powdered, was introduced into a glass

tube, and was placed in a stove, the temperature of which could be raised at pleasure. By heating this stove to 300° C., and at the same time passing a current of dry air deprived of carbonic acid, all the water which the magnesite contained was removed with certainty; but at the same time carbonic acid was disengaged, which it was requisite to collect and estimate. For this purpose the current of air was directed, at its exit from the tube, into two vials containing perfectly transparent barytes water. The carbonate of barytes collected at the conclusion of the drying was estimated in the state of sulphate; and the quantity of carbonic acid, which the weight of the sulphate represented, was added to that obtained by the following operation.

The residue which remained in the tube, after being weighed, was calcined at a strong red heat; the loss of weight indicated almost the whole of the carbonic acid contained in the mineral; the calcined residue still contained a trace of it. To determine its amount, the authors dissolved the residue in hydrochloric acid, and passed over the hot solution a current of air, which removed some traces of carbonic acid, and which were deposited in perfectly clear barytes water. Thus the whole quantity of carbonic acid which a given weight of the magnesite contained, consisted of—1, the portion removed by drying at 300°; 2, that expelled by calcination; 3, the small portion which remained in the calcined residue.

All these experiments were performed and considered with sufficient care, and gave satisfactory results. The last eleven determinations, which the authors deem most worthy of confidence, gave a mean of 250·34 as the equivalent of magnesium.

As all the errors which may be committed in such delicate analyses tend rather to lower the real number, MM. Marchand and Scheerer are of opinion, that, neglecting the insignificant fraction of thirty-four hundredths, the round number 250 may be adopted as the equivalent of magnesium, that of oxygen being 100, or 20, taking the equivalent of hydrogen as unity. According to this statement, 100 parts of magnesia consist of 60 magnesium and 40 oxygen; and 100 parts of carbonate of magnesia are constituted of 47·619 carbonic acid and 52·381 of magnesia.

The researches of MM. Marchand and Scheerer place magnesium among the number of simple substances, the equivalents of which are multiples of that of hydrogen by a whole number.

3. *New Metal, Donarium*, (Pogg. Ann., vol. lxxxii, April, 1851.)—This new metal Donarium was obtained by Dr. Bergemann, while experimenting on the Wöhlerite and Eukolite of Brevig, Norway. A mineral substance was separated, which has since been called *Orangite*, which is essentially a silicate of Donarium, of the formula $Do^2 O^3, Si O^3 + 2HO$, and affording on analysis—

Si̋	Do, O	Ca C̈	F̋e	Mg & M̋n	K & little Na	Ḣ
17·695	71·247	4·042	0·310	0·214	0·303	6·900=100·711

The metal was obtained from the oxyd by means of potassium; it formed a heavy coal-black powder, which, when dry and rubbed in a mortar acquired a metallic lustre. It burns when thrown into the flame of a lamp with a reddish light, and forms a red oxyd. Hydrochloric acid, hot or cold, has no action on the metal; and nitric acid only when

heated. Nitro-muriatic acid changes it rapidly to a red oxyd, and a small portion is held in solution. With sulphuric acid it readily forms a sulphate. The atomic weight deduced from the composition of this sulphate, is 997·4, or near that of bromine. 100 parts of the oxyd contain 13·072 of oxygen. The oxyd on charcoal alone is unaltered, and with the usual tests it gives no characteristic reaction. The bead with soda contains particles of undissolved oxyd, distinguishable with a lens by their red color. With borax or salt of phosphorus the bead is yellowish, becoming colorless on cooling.

4. *On Aridium, a new metal;* by M. Ullgren, (Oefv. of Kongl. Vet.-Akad. Förh., 1850, No. 3, p. 55; J. f. pr. Chem., lii, 443.)—This new metal is found in chromic iron, and is closely allied to iron and chromium, whence the name from *Αρης*, *Mars*, the alchemistic name of iron.

5. *Bismuth.*—R. Schneider has determined anew the equivalent of bismuth by oxydizing pure bismuth by means of nitric acid and removing the acid by heat. He obtained as a mean of eight good determinations, bismuth 89·655, oxygen 10·345. This gives for the equivalent of bismuth, 2599·95 or 2600.

6. *Alkalies.*—An article by Ebelmen on the separation of the alkalies from magnesia and on the analysis of minerals containing the alkalies, is contained in the Ann. de Ch. et de Phys., 3d ser., vol. xxx, p. 324, Nov., 1850.

II. Geology.

1. *Discovery of Fossil Fish in the Coal Formation of New Brunswick;* by Dr. C. T. Jackson.—Dr. Jackson in a letter to one of the editors, dated Boston, June 20th, announces the discovery of perfect specimens of fossil fish in the coal mine of Albert county, N. B., on the 5th of May last, and larger numbers on the 27th of May, and of Lepidodendra on the 6th of June. The following is cited from his letter:—"I returned to Boston on the 12th, with numerous fossil fishes of Hillsboro, N. B., the miners having followed up my discoveries of May last, and found even better specimens than I had myself discovered on my first visit.

You may feel interested in knowing that I have made out some of the genera and found new species of fossil fishes and that the Paleoniscus occurs abundantly associated with aquatic plants; also that a Lepidodendron, near if not exactly identical with the *L. gracile*, Br., is found with the fishes and with scattered fish scales in the same piece of the shale. Broad flat leaves like those of palms occur also in the fish shales of the coal mine and a curious blistered leaf is extremely abundant in all parts of the fish strata. These I at last traced to a stem. They appear to be new species and remind me of our aquatic floating plant, the bladder-wort of our ponds.

The occurrence of immense quantities of well preserved coprolites of fishes verifies the idea of Agassiz, that the heterocercal tailed fishes swam close to the bottom; for otherwise the form of such materials could not be preserved; for they were entire in the mud which ultimately enveloped them. There are herbivorous fishes associated with those that ate them and the excrements of some tell the tale that some

of the fishes were cannibals! Some of the coprolites I have seen connected with the anus of the fish appearing as if extruded by compression of the fish. Some of the fish appear to have been dead and partially putrid when they were enclosed in the strata, others evidently struggled hard against adverse fortune, erected their fins strongly to guard themselves from some imagined swallower, while others wiggled and squirmed in vain to free themselves from the tenaceous mud which embalmed them in their last struggle. In fact these fishes are literally embalmed and not petrified, the bitumen which so richly charges the marly or soft clay slate or shale preserving in the most delicate manner every scale, fin, and the minutest markings; the scales retain their silvery hue slightly tinted yellowish brown by the bituminous matter."

2. *Immense Coal bed.*—Mr. J. Dill has communicated to the Family Visitor a brief account of a remarkable deposit of mineral coal at Straitsville, Perry county, Ohio, which, if true, exceeds anything of the kind before discovered. He writes:—

"Reports of an immense structure of coal in the vicinity of this place, have long been circulated in Central Ohio. I first heard of it in the winter of 1848–9; it was then reported to be about ninety feet thick. Further examinations ascertained the thickness of the uncovered part, in the face of a deep ravine at 112 feet. A few days since a gentleman of high standing informed me, that an acquaintance of his, with some others, had stripped the upper surface of the bed and bored through the coal stratum to ascertain its thickness, and found it to be 138 feet."

Mr. J. W. Foster adds, in a letter to the editors, as follows:—

"Although this extent is at variance with all our previous knowledge of carboniferous deposits, yet I have no doubt that, in the main, it is true. I was recently within a day's ride of the locality, but regret that I was unable to devote the requisite time to its examination. I conversed with several intelligent persons who had seen the deposit and all concurred in representing it as one of unparalled thickness. It is exposed for several miles in the banks and along the bed of a small stream—one of the tributaries of the Hocking river. Like most of the coals of Ohio, it is highly bituminous and is more or less impregnated with iron pyrites which for manufacturing purposes, impairs its value. The deposit instead of being one bed, may be regarded as a repetition of beds; for, at intervals of a few feet, we meet with thin seams of shale, forming natural divisions. Altogether, it may be regarded as the most wonderful deposit yet brought to light."

3. *On Fossil Fish in the Coal rocks of Ohio;* by J. W. Foster, (Communicated for this Journal in a letter dated Brimfield, June 23.)

—While at Zanesville, recently, I discovered a locality in the carboniferous series, rich in the remains of fishes. Associated with them were several species of molluscs and corals, and even the delicate fronds of the Neuropteris. I have never before observed a locality where the forms of animal and vegetable life were so confusedly mingled. I have also succeeded in procuring beautifully preserved teeth from the limestone of Cambridge, belonging to this series—the existence of which I had known for several years.

Within the last few years, it has been proved that the occurrence of the remains of fishes in many of the western groups of rocks, is by no means rare. In the Clinton group at the base of the Upper Silurian, as developed in the Lake Superior district, we have detected markings similar to those in the same group in New York, made by some vertebrated animal, probably a fish. Mr. Joseph Sullivant has observed the remains of fishes consisting of teeth, scales and fins in numerous instances in the Cliff limestone of Columbus, (Upper Silurian,) and Prof. Agassiz, in a recent visit to the quarries, was enabled to collect numerous specimens, and we may hope, ere long, to receive exact information as to the character of these ancient species.

Dr. Norwood found a well-preserved jaw in the same group, at Madison, Ia. Messrs. Whittlesey and Brainard of Cleveland have brought to light well-preserved specimens from the Devonian, or perhaps subcarboniferous system of Northern Ohio; while at Zanesville and Cambridge, we have indisputable evidence of their occurrence in the true carboniferous.

4. *Sulphate and Carbonate of Copper of Bristol, Conn.*—On page 222 we failed to state that the copper ore contains both sulphuric and carbonic acids, but the fact of their chemical combination remains in doubt.

III. Zoology.

1. *On the Classification of the Crustacea Grapsoidea;* by James D. Dana.—The Grapsoidea, in the system here explained, correspond to the Cyclometopa of Edwards, excepting that we separate the Telphusa, group and place it with the Cancroidea.*

A few of the species have the fourth joint of the outer maxillipeds articulated by the inner angle with the third, as in the Cancroidea: of these we make the family Gonoplacidæ, or the Grapsoidea Cancridica.

In all the other species, this articulation is remote from the inner angle, being either near the middle of the apical margin or at the outer angle. The near universality of this character among the Grapsoidea is proof of its importance, and sustains us in removing from along side of the Gonoplacidæ the Macrophthalmi.

The Macrophthalmus and Ocypod groups are closely related, and with Doto make our *second* family the Macrophthalmidæ,—characterized by the great length of the eye-peduncles, the very narrow front, and the 2nd joint of the male abdomen narrower than the corresponding part of the sternum.

The Grapsus family—the third has the same limits as in the system of Milne Edwards. The form is subquadrate, with the lateral margin anteriorly more or less acute; the front broad; the eyes of moderate length or short; the second joint of the male abdomen usually not narrower than the corresponding part of the sternum. We give more importance than has hitherto been done to the fact of the outer maxillipeds having an oblique piliferous crest on the surface or not; and we make this characteristic the basis of a subdivision of the Grapsidæ (exclusive of the Plagusinæ) into the subfamilies *Grapsinæ* and *Sesarminæ*,

* This volume, p. 130.

the former characterized by the absence of this crest. A survey of the groups will at once show, we believe, that we follow natural lines in this subdivision. The *Plagusinæ* are distinguished by longitudinal sinuses in the front of the carapax for the inner antennæ.

The family GECARCINIDÆ—the fourth—is the same in limits as the "Gecarciniens" of Edwards,—the species are remarkable for their thick obese forms, high rounded front and antero-lateral margin, and for having the second joint of the male abdomen but slightly narrower than the corresponding part of the sternum.

The family PINNOTHERIDÆ—the fifth—differs from the "Pinnotheriens" of Edwards in the removal of the genus *Doto*, closely related to Ocypod, and also the genus *Myctiris*, an aberrant form between Pinnothera, Doto and Helœcius, but very peculiar in being narrow anteriorly, and having no distinct orbits for the retraction of the eyes. The genus *Myctiris* constitutes the last or sixth family MYCTIRIDÆ. In the Pinnotheridæ, the male abdomen is much narrower than the sternum behind, which character separates them from the Gecarcinidæ.

We do not believe in a properly lineal order in classification; yet the succession we have given to the families is a natural succession, as nearly as can be made. The *first*, Gonoplacidæ, link the Grapsoidea with the Cancroidea, and the genus Eucrate is very near Eriphia and Panopæus in form. The *second*, Macrophthalmidæ, is closely allied to the first, so much so that Marophthalmus and Gonoplax have been arranged in the same group. The *third*, Grapsidæ, are again very near the Macrophthalmidæ, and the genus Helice is almost as correctly placed with one as the other. Thence the transition is as gradual also to the *fourth* or Gecarcinidæ, and from the fourth to the *fifth* or Pinnotheridæ, and from the fifth to the *sixth* or Myctiridæ. Still, there are other relations of somewhat less prominence which this order does not exhibit. That of *Elamena* to Inachus has long been recognized.

The Gonoplacidæ are placed in the Cancer group by DeHaan, who neglected the important distinction based on the male verges. The other genera, exclusive of Pinnothera and the species related, he divides into two groups, the *Ocypus* and *Grapsus* groups, the former having the fourth joint of the outer maxillipeds articulated with the outer angle of the third, and the latter, articulated with the middle of the apical margin;—a distinction difficult to carry out and dividing natural groups, as the Gecarcinidæ, Grapsidæ, &c. His genera of the OCYPUS group, are, Doto, Scopimera, Myctiris, Gelasimus, Macrophthalmus, Cleistostoma, Cardisoma, Chasmagnathus, Helice, Uca, Ocypoda, Acanthopus (a division of Plagusia); those of the GRAPSUS group, are, Gecarcinus, Philyra (division of Plagusia), Plagusia (another division), Grapsus, Trichopus, Eriocheir, Pachysoma, Goniopsis, Platynotus, Brachynotus, Nautilograpsus, Cyclograpsus, and in his "Decas Septima," published in 1849, he unites with the group, Pinnotheres and Hymenosoma.

We add a few words on the genera of GRAPSIDÆ. Both De Haan* and Randall† have divided the Grapsus of authors into two genera, according to the *short* or *oblong* form of the third joint of the outer max-

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* Faun. Japon., p. 33, 1833.

† Jour. Acad. Nat. Sci., Philad., viii, 124, 126.

illipeds. The former are De Haan's *Grapsi*, and Randall's *Pachygrapsi;* the latter De Haan's *Goniopses* and Randall's *Grapsi.* But the length of this joint, as we have shown in many other cases, is a characteristic of small importance, and such a basis for subdivision is therefore wrong. There are two natural groups; one with arcuate sides, like *G. pictus*, and the other with straight sides like *G. cruentatus* and *G. messor;* and in each, this joint may be short or oblong. *G. variegatus*, like *G. pictus*, has the joint oblong; yet a species every way similar and hitherto referred to the *variegatus* has the same joint not longer than broad.* We hence reject this subdivision and adopt two others, viz: *Grapsus*, having arcuate sides, and *Goniograpsus*, having straight sides. The latter forms the transition to *Sesarma* and *G. cruentatus* is like the *Sesarmæ* in habit.

The genus *Cyclograpsus* of Edwards is characterized by its author as having a piliferous crest on the outer maxillipeds, though exceptions are admitted. Subsequently, M'Leay made his genus *Gnathochasmus* on the same type. Some recent authors have taken M'Leay's name for these typical species and restricted *Cyclograpsus* to the exceptions. We find no authority in the rules laid down by the British Association, or in the nature of the case, for thus perverting Cyclograpsus from its true type as first established, and we therefore make Gnathochasmus a synonym of it, and adopt a new name for the species without the piliferous crest. This we believe is due to M. Edwards.

The following is a synopsis of the Families, Subfamilies and Genera of Grapsoidea:—

CRUSTACEA GRAPSOIDEA.

1. Articulus maxillipedis externi 4tus angulo 3tii interno articulatus.

Fam. I. GONOPLACIDÆ.

Carapax transversus. Frons quartâ parte latitudinis carapacis longior, paulo deflexus, lamellatus. Antennæ internæ transversæ. Articulus abdominis *maris* 2dus sterno contiguo angustior.

G. 1. Eucrate, *De Haan.*†—Carapax antice arcuatus, parce declivis, *Panopæo* formâ antennisque affinis. Appendices *maris* sexuales e sterno ortæ abdomineque tectæ. Pedes *maris* antici breves, crassi. Oculi breves. Abdomen *maris* 5-articulatum, versus basin sterno contiguo vix angustius.

G. 2. Curtonotus, *De Haan.*‡—Carapax antice arcuatus, parce declivis, margine antero-laterali rotundato. Appendices *maris* sexuales e basi pedum ortæ, in canaliculo sterni ductæ, deinde abdomine tectæ. Oculi breves. Pedes *maris* antici prælongi.

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* The species referred to is one from Valparaiso. The *G. variegatus*, according to its description by Edwards, and the figure by Guerin, has the joint quite oblong. The Valparaiso species, which we name the *Grapsus planifrons*, has this joint no longer than broad.

† Crust. Faun. Japon., p. 36. *Geryon*, Kröyer, Tidskrift, i, (1837,) p. 15, pl. 1.

‡ De Haan, Crust. Faun. Japon., p. 20. *Pseudorhombila*, Edwards, Crust. ii, 58.

G. 3. Gonoplax, *Leach*.—Carapax latus, trapezoidalis, antice elongatè transversus, angulis anticis acutis. Appendicibus *maris* sexualibus *Curtonoto* affinis. Oculi longi. Pedes *maris* antici prælongi.

2. Articulus maxillipedis externi 4tus angulo 3tii interno non articulatus.

Fam. II. MACROPHTHALMIDÆ.

Oculi tertiâ parte latitudinis carapacis non breviores. Carapax subquadratus, sæpissimè transversus, antice latissimus, angulis anticis acutis, lateribus non arcuatis. Antennæ internæ sive transversæ sive longitudinales. Articulus abdominis *maris* 2dus sterno contiguo angustior. Articulus maxillipedis 3tius costâ obliquâ piliferâ nunquam ornatus.

1. MACROPHTHALMINÆ.—Antennæ internæ transversæ, sub fronte insitæ. Antennæ externæ basi frontem appressæ. Articulus maxillipedis externi 4tus apertus.

G. 1. Cleistostoma, *DeH.**—Carapax subquadratus, paulo transversus. Frons quartâ parte latitudinis carapacis vix brevior. Oculi longiusculi. Pedes antici *maris feminæve* breves. Articulus maxillipedis externi 3tius 2do vix minor, quadratus.

G. 2. Macrophthalmus, *Latr.*—Carapax latus, transversim rectangulatus. Frons angustissimus. Oculi longissimi. Articulus maxillipedis externi 3tius 2do multo minor.

2. OCYPODINÆ.—Antennæ internæ longitudinales, juxta frontem utrinque insitæ. Antennæ externæ fronte paulum remotæ. Articulus maxillipedis externi 4tus apertus, 3tius 2do minor.

1. *Articulus maxillipedis externi 2dus 3tio valde major.*

G. 1. Gelasimus, *Latr.*—Oculi graciles, corneâ parvulâ, parce oblongâ. Pedes *maris* antici portentosè inæqui. Manus minor debilis, digitis sæpissimè instar cochlearis excavatis aut spatulatis.

G. 2. Helœcius, *Dana.*†—Oculis habituque *Gelasimo* affinis. Pedes antici subæqui. Abdomen versus basin sterno contiguo vix angustius. Maxillipedes externi sulco lineari fere longitudinali superficie notati.

G. 3. Ocypoda, *Fabr.*—Oculi crassi, corneâ longâ, fere ad pedunculi basin productâ. Pedes *maris* antici inæqui, minoris digitis acuminatis. Abdomen basi angustum. Carapax transversus.

2. *Articulus maxillipedis externi 2dus 3tio parce major, non oblongus.*

G. 4. Scopimera,‡ *DeH.*—Corpus globoso-cubicum. Pedes *maris* antici subæqui, non crassi. Habitu *Gelasimo* affinis.

3. DOTINÆ.—Articuli maxillipedis externi 4tus et sequentes 3tio celati.

Genus Doto, *DeH.*§—Corpus subquadratum.

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* Crust. Faun. Japon., p. 26.—From κλειστος, *shut*, and στομα, *mouth*—not *Cleistotoma*.

‡ Crust. Faun. Japon., p. 24.

† Includes *Gelasimus cordiformis*.

§ Crust. Faun. Japon., p. 24.

Fam. III. GRAPSIDÆ.

Oculi tertiâ parte latitudinis carapacis breviores. Carapax subquadratus, sæpius depressus, lateribus aut rectis aut arcuatis. Antennæ internæ transversæ. Articulus abdominis *maris* 2dus sterno postico sæpius vix angustior. Articulus maxillipedis externi 3tius sive inornatus sive costâ obliquâ ornatus. Palatum lineâ elevatâ viæ efferentis limite instructum.

1. GRAPSINÆ.—Antennæ internæ fronte tectæ. Articulus maxillipedis externi 3tius costâ obliquâ in 2dum productâ non notatus.

1. *Maxillipedes externi vix hiantes.*

G 1. Pseudograpsus, *Edw.*—Articulus maxillipedis externi 3tius orbiculato-cordatus, aut subquadratus, 2do brevior. Frons dimidio latitudinis carapacis vix brevior. Carapax lateribus arcuatus.

G. 2. Eriocheir, *DeH.**—Articulus maxillipedis externi 3tius uti in *Pseudograpso*. Frons dimidio latitudinis carapacis multo brevior. Carapax subpolygonatus.

G. 3. Platynotus, *De H.*†—Articulus maxillipedis externi 3tius 2do longior, margine postico valde obliquo.

G. 4. Trichopus, *De H.*‡—Articulus maxillipedis externi 3tius latior quam longior, extus dilatatus. Pedum articuli 5tus 6tusque posticorum compressi denseque ciliati.

2. *Maxillipedes externi rhomboidicè hiantes.*

G. 5. Grapsus, *Lamk.*—Carapax transversim lineolatus, lateribus plus minusve arcuatis. Frons dimidio latitudinis carapacis brevior. Antennæ externæ juxta frontis latera oblique exsertæ. Tarsi spinulis armati.

G. 6. Goniograpsus, *Dana.*§—Carapax transversim lineolatus. lateribus rectis, postice sæpe convergentibus. Frons dimidio latitudinis carapacis longior. Antennæ externæ sub frontis margine sæpius exsertæ. Tarsi spinulis armati.

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* Faun. Japon., p. 32, 59.—The genus *Utica* of White, (Ann. Mag. Nat. Hist., xx, 206, and Crust. Voy. Samarang, 52, pl. 13, fig. 6,) appears to have the essential characteristics of Eriocheir, and like Eriocheir differs but little from *Pseudograpsus*. The front is narrow, the form subpolygonal, and it lives like E. Japonicus, in freshwater. The bushy hair on the hand of the Japan species is not *necessarily* a *generic* character. The name Eriocheir is therefore unfortunate, and it would be better for the science to substitute the name given by White.

The *E. penicillatus* of De Haan, (p. 60, pl. 11, f. 6,) appears to be a true Pseudograpsus.

† Faun. Jap., p. 34.

Brachynotus is the name of another genus by De Haan based on a Mediterranean species described by Risso, Hist. Nat. de l'Eur. Merid., v, 13. The male abdomen is but 4-jointed, the female 7-jointed; 2d and 3d joints of the outer maxillipeds of equal length, and the 3d truncate at either extremity.

‡ Faun. Jap., p. 32.—*Varuna* of Edwards, Crust. ii, 94.

§ In part, *Goniopsis* of De Haan, F. Jap., p. 33, and *Pachygrapsus* of Randall, J. Acad. Nat. Sci., Philad., viii, 126.

G. 7. PLANES, *Leach.**—Carapax non lineolatus, lævis, fere quadratus, parce oblongus. Frons rectus. Articulus maxillipedis externi 3tius latior quam longior, cordatus. Tarsi spinulis armati.

G. 8. HEMIGRAPSUS, *Dana.*†—Carapax non lineolatus, fere lævis, lateribus plus minusve arcuatis. Frons rectus aut rectiusculus, antennis internis tranversis. Articulus maxillipedis externi 3tius fere orbiculato-cordatus. Tarsi inermes.

G. 9. CYRTOGRAPSUS, *Dana.*—Carapax gibbosus, subhexagonus non lineolatus. Frons sursum sinuosus, antennis internis obliquis, inplicis frontis insitis. Articulus maxillipedis externi 3tius subor-biculato-cordatus. Tarsi inermes.

2. SESARMINÆ.—Antennæ internæ fronte tectæ. Articulus maxillipedis externi 3tius costâ obliquâ in 2dum productâ notatus.

1. *Articulus maxillipedis externi 3tius apice rotundatus.*

G. 1. SESARMA, *Say.*‡—Carapax quadratus, sæpe partim lineolatus, lateribus rectis, fronte rectè prærupto. Abdomen *maris* versus basin sterno contiguo vix angustius. Tarsi sæpe armati.

G. 2. SARMATIUM, *Dana.*—Carapax subquadratus, lateribus arcuatis, fronte curvatim declivi. Abdomen *maris* versus basin sterno contiguo vix angustius. Tarsi inermes.

2. *Articulus maxillipedis externi 3tius apice truncatus et sæpe excavatus.*

G. 3. CYCLOGRAPSUS, *Edw.*§—Carapax lævis, medio planus, ad margines anteriores declivis, lateribus arcuatis, integris. Abdomen *maris* versus basin sterno contiguo vix angustius.

G. 4. CHASMAGNATHUS, *DeH.*‖—Carapax convexus, subquadratus, lateribus arcuatis et antice emarginatis, fronte curvatim declivi. Oculi breves. Abdomen *maris* versus basin sterno contiguo parce angustius.

G. 5. HELICE, *DeH.*¶—Carapax quadratus, lateribus parallelis, rectis. Oculi longiusculi. Abdomen *maris* versus basin sterno contiguo multo angustius.

3. PLAGUSINÆ. Antennæ internæ sinubus frontis longitudinalibus apertæ.

G. 1. ACANTHOPUS, *De H.***—Corpus valde depressum. Articulus maxillipedis externi 3tius oblongus, parvus, apice 2di multo angustior. Ramus maxillipedis 1mi internus apice angustus et not transversus.

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* Mss. Mus. Brit.; the genus is recognized in Bowdich's "Madeira and Porto Santo," p. 151; and more lately in Bell's Brit. Crust., p. 133.—*Nautilograpsus* of Edwards, Crust. ii, 89.

† *Grapsus* (subgenus) of De Haan, F. Jap., p. 31; *Cyclograpsus*, in part, of Edwards, Crust. ii, 77.

‡ Jour. Acad. Nat. Sci., i, 76, 1817. *Pachysoma*, of De Haan, Faun. Japon., p. 33.

§ Crust. ii, 77.—*Gnathochasmus*, of M'Leay, Smith's Illust. Zool. S. Africa, and Cat. Crust. Brit. Mus. by A. White, 1847, 40.

‖ Faun. Japon., p. 27.

¶ Faun. Japon., p. 28.

** Faun. Japon., p. 29. Corresponds to *Plagusia clavimana*.

G. 2. PLAGUSIA, *Latr.**—Corpus minus depressum, crassius. Articulus maxillipedis externi 3tius apice 2di vix angustius, raro longior quam latior. Ramus maxillipedis 1mi internus apice transversus.

FAM. IV. GECARCINIDÆ.

Oculi breves. Carapax obesus, paulo transversus, antice latus, curvatim declivis, lateribus arcuatis poneque oculos large rotundatis, vix dentatis. Antennæ internæ transversæ. Articulus abdominis maris 2dus sterno contiguo vix angustior. Articulus maxillipedis externi 3tius costâ obliquâ piliferâ non ornatus. Palatum lineâ elevatâ viæ efferentis limite non instructum.

1. UCAINÆ. Articulus maxillipedis externi 4tus apertus.

1. *Maxillipedes externi non hiantes.*

G. 1. UCA, *Leach.*—Articulus maxillipedis externi 4tus angulo 3tii externo insitus.

G. 4. GECARCINUCUS, *Edw.*†—Articulus maxillipedis externi 4tus marginis medio apicalis 3tii insitus.

2. *Maxillipedes externi rhomboidicè hiantes.*

G. 3. CARDISOMA, *Latr.*—Articulus maxillipedis externi 4tus apice 3tii externo insitus.

G. 4. GECARCOIDEA, *Edw.*—Articulus maxillipedis externi 4tus marginis medio excavato apicalis 3tii insitus.

2. GECARCININÆ. Articuli maxillipedis externi 4tus et sequentes 3tio celatus.

G. 1. GECARCINUS.

FAM. V. PINNOTHERIDÆ.

Oculi breves, orbitis insiti, raro non retractiles. Carapax sive obesus sive depressus, raro paulo oblongus et interdum parce rostratus, lateribus valde rotundatis. Antennæ internæ aut transversæ aut obliquæ. Abdomen *maris* angustum, versus basin sterno contiguo valde angustius. [Species omnes parvæ.]

2. PINNOTHERINÆ. Articulus maxillipedis externi 2dus parvulus aut obsoletus. Corpus sive obesum sive depressum.

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* *Plagusia* and *Philyra* of De Haan, Faun. Japon., p. 31; the latter genus in his system including *Plagusia depressa* of authors, and the former the *P. squamosa*. The distinction between his two genera consists in this; the palpus of the outer maxillipeds in *Plagusia* has a flagellum, and that of *Philyra*, none. The name *Philyra* belongs to another genus of earlier date, instituted by Leach; moreover, the resemblance between the species of these groups is so close in other characters, that we hardly consider the distinction important as a generic character.

† Jacquemont's Voy. dans l'Inde, plate 1.

1. *Oculi approximati. Fossæ antennales conjunctæ.*

a. Pedes 8 postici sat graciles, subæqui.

G. 1. PINNOTHERA, *Latr.*—Corpus obesum. Carapax superficie integerrimus, nunquam areolatus. Oculi normales.

G. 2. FABIA, *Dana.*—Corpus obesum. Carapax superficie anticâ pone orbitas suturâ divisus. Oculi normales.

G. 3. XENOPHTHALMUS, *White.**—Corpus obesum, fronte incisionibus duabus profundis oculos gerentibus instructo.

G. 4. XANTHASIA, *White.*†—Corpus depressum, supra fere planum margineque elevato utrinque instructum, fronte paulo producto. Oculi normales.

b. Pedes 4ti longiores et multo validiores.

G. 5. PINNIXA, *White.*‡—Corpus portentosè transversum.

2. *Oculi sat remoti. Fossæ antennales septo latiusculo sejunctæ. Articulus maxillipedis externi 2dus fere dimidii 3tii longitudine.*

G. 6. PINNOTHERELIA, *Lucas.*§—Pedes 8 postici sat graciles, subæqui. Corpus suborbiculare.

2. HYMENICINÆ. Corpus sæpius parce rostratum, depressum. Articulus maxillipedis externi 2dus dimidio 3tii major.

G. 1. HYMENOSOMA, *Leach.*—Carapax suborbiculatus, angulo extra-orbitali acuto. Frons angustissimus, non lobatus, oculis valde approximatis.

G. 2. HALICARCINUS, *White.*‖—Carapax suborbiculatus, angulo extra-orbitali nullo. Frons tridentatus, antennis internis inter dentes se porrigentibus, oculis remotioribus. Articulus maxillipedis externi 3tius 2do paulo major.

G. 3. HYMENICUS, *Dana.*¶—Carapax suborbiculatus, angulo extra-orbitali nullo. Frons productus, simplex aut lobatus, antennarum basin celans, oculis remotioribus. Articulus maxillipedis externi 3tius 2do paulo major. Pedes gracillimi.

G. 4. ELAMENA, *Edw.*—Carapax subtriangulatus, paulo oblongus, paulo rostratus, fronte antennas internas celante. Articulus maxillipedis externi 3tius 2do minor.

FAM. VI. MYCTIRIDÆ.

Corpus obesum. Carapax fronte perangustus, orbitis carens; antennæ internæ longitudinales.

Genus MYCTIRIS, *Latr.*

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* White, Ann. Mag. Nat. Hist., xviii, 178, and Voy. of Samarang, p. 63. The genus *Fabia* forms a transition from Pinnothera to Xenophthalmus; it includes the *P. chilensis.*

† Ann. Mag. Nat. Hist., xviii, 176.

‡ Ann. Mag. Nat. Hist., xviii, 177. Includes Say's *Pinn. cylindricum*, Jour. Ac. Nat. Sci., Philad., i, 452.

§ Crust. of D'Orbigny's S. Amer., p. 24. The genus forms a transition to the Gecarcinidæ.

‖ Ann. Mag. Nat. Hist., xviii, 178.

¶ The genus *Hymenosoma* belongs to the Cape of Good Hope, *Halicarcinus* to the extremity of S. America, and *Hymenicus* to New Zealand.

2. *Note on the genera Hexapus and Arges of De Haan;* by J. D. DANA. —The genus *Hexapus* of De Haan, in his first publication of its characters, (in Decade I. and II. of the Fauna Japonica, pp. 5 and 35,) is arranged near Pinnothera, which it resembles in its short obese form and small size. But in his last Decade, published in 1849, which contains his final remarks on classification, at p. xiv, the genus is referred to the vicinity of Pilumnus.—The outer maxillipeds are as in Pilumnus. The genus is peculiar in the 5th pair of legs being obsolete. The species is the *H. sexpes*, (Jap., p. 63 and pl. 11, f. 6, *Cancer sexpes* of Fabricius, Ent. Syst., Suppl., p. 344, f. 37.)

The genus *Arges* of De Haan, (Faun. Japon., p. 21,) includes only a fossil species. It is Cancroid in its outer maxillipeds and near Pilumnus and also Menippe. The abdomen in both sexes is 7-jointed; in the male oblong-trigonal, in the female ovate. The lateral margins of the carapax are parallel and entire, and the general form is much like that of *Cyclograpsus Audouinii* and the allied. Distance between the eyes one-fifth the breadth of the thorax.—Sp. *A. parallelus* (F. Jap., p. 52, and pl. 5, f. 4) from Japan.

3. *On the Resuscitation of Frozen Fish;* by Prof. O. P. HUBBARD. —With a previous notice on this very interesting subject in the Am. Journal, vol. x, p. 132, I made a request that correspondents would communicate other examples of the kind. In reply I have received the following letter from Prof. J. P. Kirtland, M.D., which details a remarkable instance of resuscitation.

To Prof. O. P. HUBBARD, *Dear Sir*:—In accordance with your request, as expressed in the foregoing article, I will communicate in detail some facts in regard to the resuscitation of frozen fish.

To persons familiar with the locality, it is known that a brook or small rivulet arises from springs, among the granite hills between Durham and Haddam in the state of Connecticut and ultimately discharges itself into Connecticut river a little south of the city of Middletown. In its passage among the high bluffs, it in one instance winds its way through a marsh of several acres in extent, immediately below which, a high dam is thrown across it from bluff to bluff. This raises the water some eight or ten feet over the marsh and forms a reservoir for the purpose of supplying a series of mills on the stream below, during the droughts of summer. At the approach of winter the artificial outlet is usually closed by a gate and the water collects till it is wanted during the following season.

In this pond or reservoir had accumulated large numbers of the common eel and as they were usually restrained from descending the stream at the approach of winter, as is their habit when left to themselves, many of them had attained a large size.

The autumn and winter of 1819–20 or of the succeeding year (which, I am not certain,) was distinguished for the scanty supplies of rain and the low stages of water in the streams in that section of country. Winter set in with heavy and repeated falls of snow, the drought still continuing. A heavy body of ice formed on this pond and upon it rested eighteen inches or more of snow. About mid-winter the mill owners drew off all the remaining water and the ice rested on the soft mud at the bottom. The immense pressure seemed to incommode the eels in their winter quarters and they commenced collecting in the

small center channel which constituted the original stream and descended through the gateway of the dam in search of a more favorable retreat.

Below the dam the brook descends from one level to another among the rocks, forming little pools one or two feet in depth and a few feet wide, in which large quantities of fallen leaves had accumulated. Beneath these the eels retreated. The weather had been cold for many weeks and the surface of the pools was thickly congealed and frequently involved the leaves and the eels.

On an extreme cold morning my brother-in-law, Caleb Atwater, now of Atwater in Ohio, a Mr. Hall of Durham and myself visited the place, prepared for a fishing exploit—not however in accordance with the nice directions of that prince of fishermen, Isaac Walton, but armed with an axe, shovels and baskets.

We were not the first to visit the ground. The foxes had ranged over them and the remains of many an half-devoured eel showed that Reynard is a skillful disciple of honest Isaac though perhaps he never read Isaac's interesting book.

Our operations commenced by cutting large portions of the ice from the surface of the pools—then we found very little difficulty in crowding the eels with the wet leaves into the basket by means of our shovels. A dozen or more were frequently taken at a time. The severity of the weather rendered them rather dull though they were able to swim with some activity.

As soon as they were secured in the basket they were thrown among the snow, and as the temperature was very little above zero they were at once congealed without a struggle.

We returned at evening to my residence in Durham, with my sleigh loaded to its utmost capacity with frozen eels. The quantity was not less than eight or ten bushels.

During the night they were placed in a cold and exposed room and were literally as stiff and almost as brittle as icicles. The next morning a tub was filled with them into which was poured a quantity of water drawn from the well and they were then placed in a warm stove-room for the purpose of thawing. In the course of an hour or two the family were astonished to find them resuscitated and as active as if just taken during the summer.

The experiment was tried with a number of tubs full during the day and with similar results.

How long they would have retained their vitality sufficient to allow of resuscitation I know not—but the presumption is that it would not diminish so long as they were preserved at a temperature much below the freezing point.

The eel is known to be more tenacious of life than many more delicate species of fish, yet it is believed that even tenderer kinds can be resuscitated after having been suddenly frozen at the moment they are captured.

We should be gratified to learn from some of the people about Markham's pond whether a similar occurrence has been known in recent years, of the descent of the eels from the reservoir. It had once happened a few years previous to that above noticed.

Cleveland, Ohio, July 15, 1850. J. P. KIRTLAND.

IV. Astronomy.

New Planet Irene, (Gould's Astr. Jour.)—On the 19th May, 1851, Mr. J. R. Hind of London, discovered a new planet resembling a star of the 9th magnitude. Its place May 19, $12^h\ 52^m\ 36^s$ m. t. Gr., was in R. A. $16^h\ 4^m\ 10^s{\cdot}41$ and South decl. $13°\ 23'\ 34''{\cdot}9$.

The following elements of its orbit are by Mr. James Ferguson of U. S. National Observatory.

Mean Longitude, June 10.0, 1851, m. t. Gr.	41° 57′ 9″·5
Longitude of node, - - -	87 47 46″·2
" perihelion, - -	191 8 27 ·5
Inclination, - - - -	8 37 35 ·7
Angle of excentricity, - -	8 40 50 ·5
Semi-axis major, - - -	0·4069322
Mean daily motion, - - -	870″·18

This is the fourth planet discovered by Mr. Hind, and the fourteenth of the group between Mars and Jupiter.

"Sir John Herschel, who was requested by Mr. Hind to give a name to the planet, has proposed the name *Irene* (*Εἰρήνη*) in allusion to the peaceful sentiments which should be fostered by the great industrial exhibition now holding in London, where the planet was discovered."

The planet Irene was also discovered independently, by M. Gasparis, on the 24th of May, 1851.

V. Miscellaneous Intelligence.

1. *Smithsonian Institution.*—The following observations on the registry of Periodical Phenomena, have been issued in a circular by the Smithsonian Institution: and may prove useful to many of our readers, as well as to the cause of science.

Registry of Periodical Phenomena.—The Smithsonian Institution, being desirous of obtaining information with regard to the periodical phenomena of Animal and Vegetable life in North America, respectfully invites all persons who may have it in their power, to record their observations, and to transmit them to the Institution. The points to which particular attention should be directed, are the first appearance of leaves and of flowers in plants; the dates of appearance and disappearance of migratory or hybernating animals, as Mammalia, Birds, Reptiles, Fishes, Insects, &c.; the times of nesting of Birds, of moulting and littering of Mammalia, of utterance of characteristic cries among reptiles and insects, and any thing else which may be deemed noteworthy.

A list of plants is appended, to which particular reference should be had in making observations. It has been prepared from materials furnished by Dr. John Torrey and others, and will be found to contain many species distributed throughout the United States, together with a number indigenous to, or cultivated in Europe. For the present, attention may be paid alone to the time of flowering of these species, this period in all cases being indicated by the first appearance of the anther in the expanding flower.

The Smithsonian Institution is also desirous of obtaining detailed lists of *all* the animals and plants of any locality throughout this continent. These, when practicable, should consist of the scientific names, as well as those in common use; but when the former are unknown, the latter may alone be employed. It is in contemplation to use the information thus gathered, in the construction of a series of tables, showing the geographical distribution of the animal and vegetable kingdoms in North America.

List of Plants to be particularly observed.

Acer rubrum, L., Red or soft maple.
—— pseudo-platanus, L., European sycamore.
—— saccharinum, L., Sugar maple.
Achillea millefolium, L., Millefoil or yarrow.
Actea rubra, Willd., Red baneberry.
—— alba, Bigelow, White baneberry—necklace weed;
Asclepias (syriaca) cornuti, L., Milkweed.
Æsculus hippocastanum, L., Horsechesnut, (fruit rough and prickly.)
—— glabra, Willd., Ohio Buckeye, (fruit rough and prickly.)
—— pavia, or flava, Ait., Yellow buckeye; (fruit smooth.)
Ailanthus glandulosus, Tree of heaven.
Amelanchier canadensis, Torr. and Gray, Shad bush, serviceberry.
Ampelopsis quinquefolia, Michx., American ivy—Virginia creeper.
Alisma plantago, L., Water plantain.
Amygdalus nana, L., Flowering almond.
Anagallis arvensis, L., Pimpernel, Poor man's weather glass.
Anemone nemorosa, L., Wind flower; wood anemone.
Aplectrum hyemale, Nutt., Putty root, or Adam and Eve.
Apocynum androsæmifolium, L., Dogbane.
Aquilegia canadensis, L., Wild columbine.
Amaryllis atamasco, L., Atamasco lily.
Arethusa bulbosa, L., Arethusa.
Arum triphyllum, L., Indian turnip.
Aristolochia sipho, D'Her., Dutchman's pipe.
Azalea nudiflora, L., Common red honeysuckle.
Bignonia (Tecoma) radicans, Juss., Trumpet creeper.
Catalpa bignonioides, Walt., Catalpa tree.
—— Indian bean.
Caltha palustris, L., Marsh marigold.
Carpinus americana, Michx., Hornbeam, ironwood.
Celastrus scandens, L., Bitter sweet, wax work.
Convolvulus purpureus, L., Common morning glory.
Cercis canadensis, L., Red bud; Judas tree.
Chelidonium majus, L., Celandine.
Chionanthus virginica, L., Fringe tree.
Cimifuga racemosa, Ell., Black snake root; rattle snake root.
Claytonia virginica, L., Spring beauty.
Corchorus japonicus, Yellow rose; (flowers all the year.)
Cornus florida, L., Flowering dogwood. (The time of expansion of the real flower, not of the white involucre.)
Cratægus crus-galli, L., Cockspur thorn.
—— coccinea, L., Scarlet fruited thorn.
—— oxycantha, L., English hawthorn.
Cynoglossum officinale, L., common hound's tongue.
Dentaria laciniata, Muhl., Cut leaved toothwort.
Dicentra cucullaria, D. C., Dutchman's breeches.
Digitalis purpurea, L., Purple fox-glove.
Draba (Erophyla) verna, L., Whitlow grass.
Epigæa repens, L., Trailing arbutus; ground laurel.
Erythronium americana, Smith, Dog tooth violet, or adder's tongue.
Geranium maculatum, L., Cranesbill.
Gentiana saponaria, L., Soapwort gentian.
Gleditschia triacanthos, L., Three thorned acacia, honey locust.
Gillenia trifoliata, Mœnch., Indian physic.
Gymnocladus canadensis, Lam., Kentucky coffee-bean tree.
Halesia tetraptera, Willd., Snow-drop tree.
Hepatica triloba, Chaix., Round lobed liverwort.
Houstonia cœrulea, Hook, Bluets, innocence, &c.
Hypericum perforatum, L., St. John's wort.
Hydrangea arborescens, L., Wild hydrangea.
Iris versicolor, L., Large blue flag.
Juglans regia, L., English walnut.
—— nigra, L., Black walnut.
Kalmia latifolia, L., Mountain laurel.
Lamium amplexicaule, L., Dead nettle.
Laurus benzoin, L., Benzoin odoriferum, Nees., Spice bush, Benjamin bush.
Lappa major, (Arctium lappa,) Gærtn., Common burdock.
Ligustrum vulgare, L., Common privet.
Lobelia cardinalis, L., Red cardinal flower.
Lonicera periclymenum, L., Foreign spurs.
—— sempervirens, Ait., trumpet honeysuckle.

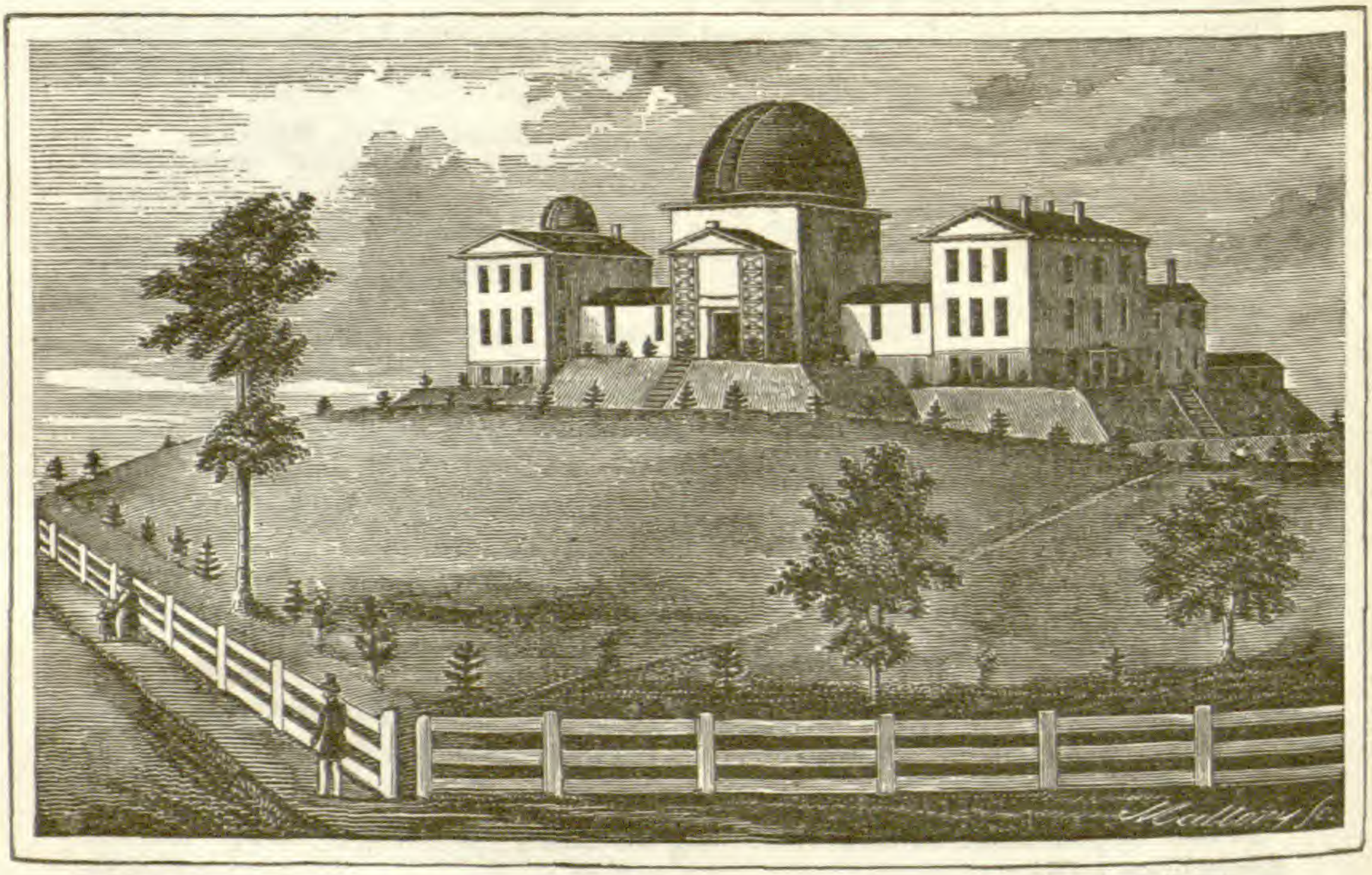
Lonicera tartarica, L., Foreign spurs.
Linaria vulgaris, Mill., Common toad flax.
Lupinus perennis, L., Wild lupine.
Lilum philadelphicum, L., Wild lily.
Liriodendron tulipifera, L., Tulip tree, American poplar.
Magnolia glauca, L., Small or laurel magnolia, sweet bay.
Morus rubra, L., Red mulberry.
Nuphar advena, Ait., Yellow pond lily, splatterdock.
Nymphæa odorata, Ait., Sweet scented water lily.
Orontium aquaticum, L., Golden club, neverwet.
Oxalis violacea, L., Violet wood sorrel.
Platanus occidentalis, L., Buttonwood, sycamore.
Persica vulgaris, L., Peach.
Podophyllum peltatum, L., Mandrake, May apple.
Pentstemon pubescens, Sol., Downy pentstemon.
Pontederia cordata, L., Pickerel weed.
Populus tremuloides, Michx., American aspen.
Pogonia ophioglossoides, Nutt., Adder's tongue.
Ptelea trifoliata, L., Shrubby trefoil.
Pulmonaria (Mertensia) virginica, D. C., Lungwort.
Pyrus communis, L., Common pear tree.
Pyrus malus, L., Common apple tree.
Quercus alba, L., White oak.
Rhamnus cathartica, L., Common Buckthorn.
Rhus cotinus, L., Smoke tree.
—— typhina, L., Staghorn sumac.
Rhus glabra, L., Smooth sumach.
Ribes rubrum, L., Currant.
—— grossularia, L., Gooseberry.
Robinia pseud-acacia, L., Common locust.
—— viscosa, Vent, Clammy locust.
Rosa centifolia, L., Hundred leaved or cabbage rose.
—— Carolina, L., Swamp rose.
Rubus odoratus, L., Purple flowered raspberry.
Sagittaria sagittifolia, L., Arrow weed.
Sambucus canadensis, L., Common elder.
—— nigra, L.
Sanguinaria canadensis, L., Blood root.
Saponaria officinale, L., Soapwort, bouncing bet.
Sarracenia purpurea, L., Side-saddle flower.
Saxifraga virginiensis, Michx., Early saxifrage.
Sassafras officinale, Nees., Sassafras.
Silene pennsylvanica, Michx., Wild pink.
Smilacina bifolia, Ker., 2 leaved Solomon seal.
Staphylea trifolia, L., American bladder nut.
Syringa vulgaris, L., Lilac.
Symplocarpus fœtidus, Salisb., Skunk cabbage.
Tilia americana, L., Bass wood, white wood, American lime, or linden.
Tradescantia virginica, L., Spider-wort.
Ulmus americana, L., American elm.
Verbena hastata, L., Blue vervain.
Viburnum opulus, L., Snowball bush.
—— opulifolium, Mx., Nine bark.
Viola lanceolata, L., Lance leaved violet.
—— cucullea, Ait., Hood leaved violet.
Vitis æstivalis, Mich., Summer grape.

First appearance of the following animals, and if possible, time of depositing eggs.

Pandion carolinus, Gm., Fish hawk.
Hirundo purpurea, L., Martin.
Tardus migratorius, L., Robin.
Sialia Wilsonii, Sw., Blue bird.
Agelaius phoeniceus, L., Red wing blackbird, and any other species of birds.
Salmo salar, L., Salmon.
Alosa, Shad.
Acipenser, Sturgeon.
Cry of toads and frogs.
—— Catydid.
—— Locust. (Cicada.)
Appearance of fire-flies.

2. *The Cambridge Observatory*, (Contributed for this Journal, through J. Smith Homans, Esq., Boston.)—This Observatory is situated on a commanding eminence called Summer House Hill, the summit of which is about fifty feet above the plain on which are erected the buildings of the University. This height is found to give from the dome an horizon almost uninterrupted to within two or three degrees of altitude. The grounds appropriated to the use of the Observatory comprise about six and a half acres. It is distant nearly three-fourths of a mile northwest from University Hall, and three miles and a half in the same direction from the State House in Boston.

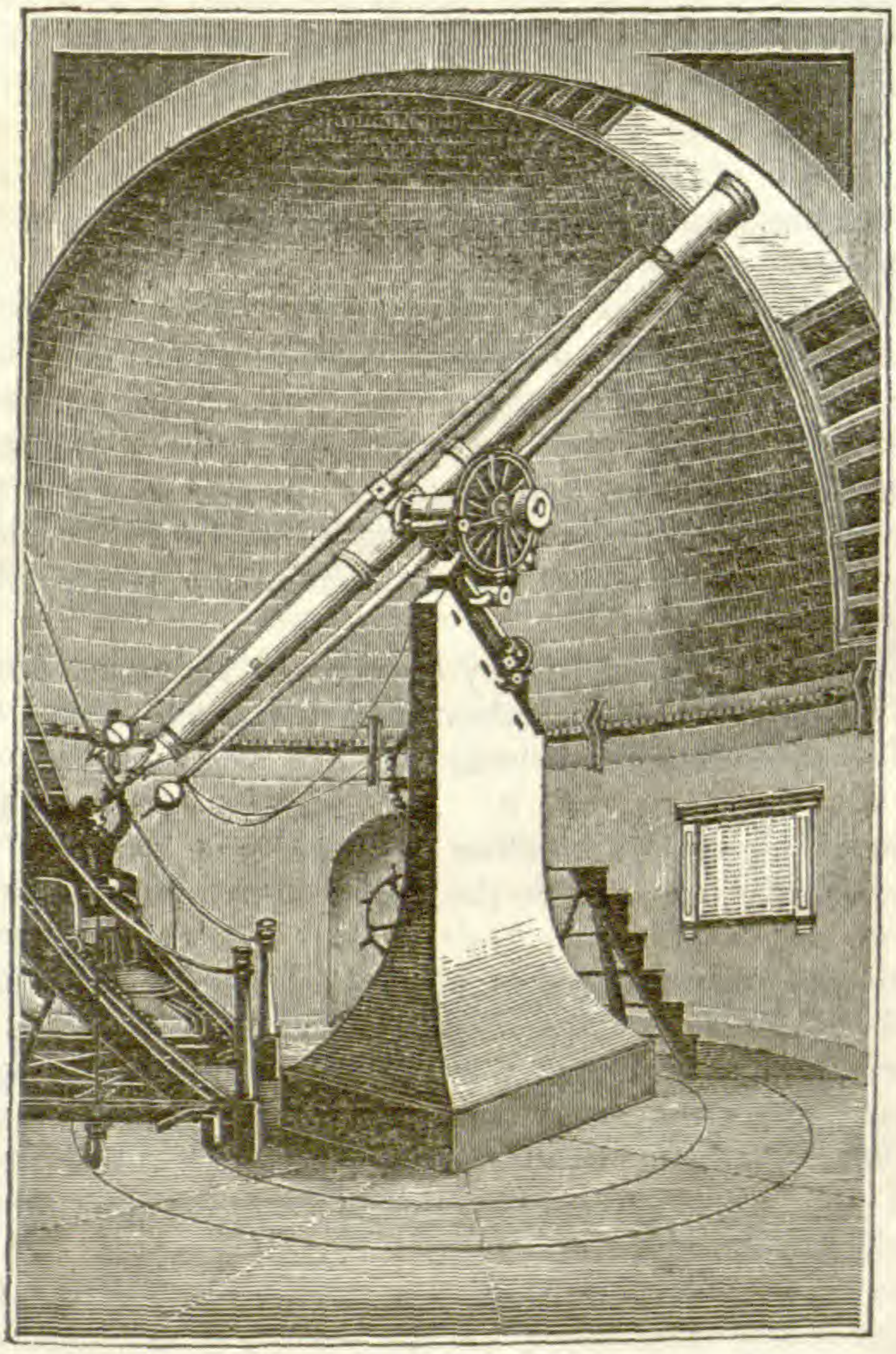
The wonder and admiration caused by the unexpected appearance of the great comet in March, 1843, was a great incentive to, and indirectly, one of the principal causes of the erection of this now celebrated Observatory, although for many years before it had been a favorite project with John Q. Adams, Nathaniel Bowditch, and other distinguished advocates of astronomical science. But few decisive steps were taken, however, until the sudden appearance of this brilliant comet, in 1843, when it was found that the instruments in Cambridge were entirely inadequate to make accurate observations on such a body. This aroused the public-spirited citizens of Boston to a sense of the importance of an Astronomical Observatory, with instruments of sufficient accuracy to make the necessary observations on the heavenly bodies. Accordingly,



an informal meeting was held in the office of the American Insurance Company, Boston, by several public-spirited individuals who were interested in the cause. Soon after, a large meeting of merchants and others was held in the hall of the Marine Society, where it was resolved to raise by subscription the funds necessary for procuring an equatorial telescope of the first class, and twenty-five thousand dollars were immediately subscribed. Mr. David Sears, of Boston, headed the list by a donation of five hundred dollars for this object, besides giving five thousand dollars for the erection of a suitable tower to contain this instrument. Another gentleman of Boston subscribed one thousand dollars towards the telescope; eight others contributed five hundred dollars each, for the same object; eighteen gentlemen gave two hundred each, and thirty others gave the sum of one hundred dollars each. The American Academy of Arts and Sciences made a donation of three thousand dollars, and the Society for the Diffusion of Useful Knowledge gave one thousand. Besides these, the principal Insurance Companies of Boston contributed largely. The American, Merchants', and Na-

tional Insurance offices, and the Humane Society, gave five hundred each; two other companies subscribed three hundred; and two others gave, respectively, two hundred and fifty, and two hundred. Thus in a short time an amount was subscribed sufficient for procuring the instrument which has contributed so much to the advancement of astronomy generally, besides reflecting so much honor on the country at large.

The Sears Tower.—The engraving annexed is a correct representation of the Grand Refractor, which is placed in the Sears Tower, or central building of the Observatory, and in the preceding sketch a correct view is given of the South front of the Observatory and its two wings.



The site of the Observatory was purchased by the corporation of Harvard University. The Sears Tower, so called in honor of David Sears, whose generous donation we have already mentioned, is built of brick, on a foundation of granite laid with cement. It is thirty-two feet square on the outside, while on the inside the corners are gradually brought to a circular form for the better support of the dome, forming a massive arch. This dome, covering the grand equatorial, is a hemisphere of thirty-two feet interior diameter, made with stout ribs of plank, and covered externally with copper. There is an opening five

feet wide, and extending a few degrees beyond the zenith; which is closed by weather-proof shutters, and worked by means of an endless chain and toothed wheels.

On the lower side of this dome is affixed a grooved iron rail, and on the granite cap of the wall is placed a similar rail; between these grooves are placed eight iron spheres, accurately turned, on which the dome is revolved. The apparatus for moving the dome consists of toothed wheels, geared to a series of toothed iron plates, fastened to its lower section. By means of this the whole dome, weighing about fourteen tons, can be turned through a whole revolution, by a single person, in thirty-five seconds. In this dome are placed the "Grand Refractor," and one or two smaller instruments. The Comet Seeker, a small instrument of four inches aperture, by Merz, is used from the balconies of the dome. This is the instrument with which the younger Bond has discovered no less than eleven telescopic comets, before intelligence had reached him of their having been seen by any other observer. From these balconies a most extensive and beautiful view of the neighboring towns, meets the eye.

On either side of the tower is a large wing. Of these the eastern is used as a dwelling for the observer; the western, on which is placed the smaller dome, is used for magnetic and meteorological observations. This wing was erected in the years 1850–51, and adds greatly to the architectural beauty of the Observatory. In this dome is placed the smaller equatorial, of five feet focal length, and an object-glass of four and one-eighth inches, made by Merz, which is a remarkably fine instrument.

The "Grand Refractor," justly considered second to none in the world, has already become celebrated in the hands of the skillful and scientific director and his assistant, from the many brilliant discoveries which have been made with it. Among these we may particularly mention the new ring and satellite of the planet Saturn. It has also enabled the observers to resolve the principal nebulæ, particularly those in the constellations Orion and Andromeda. The object-glass was made at the celebrated manufactory of Merz and Mahler, in Munich, Bavaria, who also were the makers of the celebrated telescope at the Pulkova Observatory, which is of the same size and mounting as that in Cambridge. The same artists also made the Washington and Cincinnati equatorials, besides many others of a smaller size in the United States. The extreme diameter of this object-glass is fifteen and a half inches, although the effective diameter is only fourteen and ninety-five hundredths inches: the focal length is twenty-two feet six inches; the total weight nearly three tons; yet the friction is so successfully relieved by the judicious arrangement of wheels and counterpoises, that it could be pointed to any quarter of the heavens by the finger of a child.

A siderial motion is communicated to the telescope by clock-work, by which means an object may be constantly kept in the field of view, which essentially aids the observer in delicate examinations of celestial objects. The right-ascension is read off by means of an hour circle, eighteen inches in diameter, reading to one second of time by a vernier, while the declination circle is twenty-six inches in diameter, reading also to one second of time or four seconds of arc. The total

cost of the instrument was $19,842. The object-glass arrived in Cambridge on the 4th of December, 1846, but the tube and mounting did not arrive until the 11th of June following. The instrument was mounted on the 23d of June, 1847, and on the evening of the same day was first pointed to the heavens.

The tube of the telescope is of wood, veneered with mahogany and polished on the outside. Within, it is lined with paper, and is strengthened with iron diaphragms. The flexure of the tube is counteracted and its balance preserved by two brass rods seventeen feet in length, having at their extremities nearest the eye-end, brass spheres filled with lead, eight inches in diameter. These rods turn on a universal joint near the middle or centre of motion, and oppose the influence of gravitation on the longer and heavier part of the tube in every position. The centre of motion of the whole instrument is twelve feet nine inches above the floor of the dome. The focal length of the finder telescope is forty-five inches, and its aperture three inches.

The transit circle is by Sims of London. The object-glass, by Merz, is four and one-eight inches aperture, and sixty-five inches focal length. The circles are four feet in diameter, being cast in one piece, and are both graduated on silver from 0° to 360° into five minute spaces, which are again subdivided by micrometers, a single division of the micrometer head being equal to one second of arc, and may be read to two-tenths of a second.

Besides these, the Observatory is furnished with many smaller instruments, and a complete set of meteorological instruments, an astronomical clock, and siderial chronometers.

One of the most ingenious contrivances connected with the Observatory is the "observer's chair," invented by the director. By means of this chair, the observer can transport himself to any part of the dome without moving from his seat.

The new method of finding the motion of the earth has been tried at the Observatory, and also by Prof. Horsford, at the Lawrence Scientific School.

During the Summer of 1848, the director being engaged with the United States Coast Survey in determining differences of longitude, turned his attention to the electro-magnetic method of recording astronomical observations. The apparatus which it has been found convenient to adopt at this Observatory, consists of a *Grove's battery*, a *circuit-breaking siderial clock*, and a "*spring-governor*." These are connected by means of copper wires, leading to all the principal instruments.

The *spring-governor* is a machine devised to carry a *cylinder* with an equable rotary motion, so that it may make one entire revolution in one minute of siderial time; on this cylinder the commencement and termination of each second of the astronomical clock is recorded in exact coincidence with the beats of the clock, the observer at each telescope is furnished with a break-circuit key, by means of which he is enabled to cause a record of his observation to be made on the paper covering the cylinder of the spring-governor among the second marks of the clock, in such a manner that the tenths, and even hundredths of a second may be read off without difficulty, as the sheet of paper, when

unrolled, presents the vertical columns in even minutes, and the horizontal in seconds.

The clock signals are also readily connected with the lines of the telegraph offices, by means of properly arranged switches, so that in effect the beats of the Cambridge clock are as distinctly heard at the offices in Boston, Lowell, Burlington, and elsewhere, as they are within a few feet of the clock, the only limit being the power of the battery; by commencing at the even minute, the time is given all along the line, and this is found very convenient in regulating the starting of the Railroad trains. This method has been subjected to a long and satisfactory trial, and is now considered as a permanent regulation in this Observatory.

The instrument is mounted according to the German form, which has been objected to from the fact that it requires reversal whenever the object under examination crosses the meridian. This is felt as a practical inconvenience in the Cambridge equatorial, only in small zenith distances, since in most instances the telescope passes the meridian by more than an hour of right ascension, and always by more than two hours in southern declinations.

There are but one or two points in which the instrument has been found susceptible of improvement. The arrangement of both the declination and hour circles is inconvenient, causing some needless trouble in reading off the angles.

3. *The Solar Eclipse.*—The solar eclipse of July 28, was observed at Cambridge, Mass., as follows:

For the beginning, expressed in mean solar time of the Observatory.

By R. T. Paine, using a refracting telescope of 54 in. focal length and 3 in. aperture, power 40—$7^h\ 49^m\ 35{\cdot}28^s$.

By S. C. Walker, equatorial refracting telescope of $4\frac{1}{2}$ in. aperture and 5 feet focal length, power 50—$7^h\ 49^m\ 35{\cdot}34^s$.

By W. C. Bond, Daguerreotype telescope with achromatic eye-piece, focal length 9 feet, Sun's image thrown on a white field—$7^h\ 49^m\ 38{\cdot}97^s$.

By C. W. Tuttle, comet-seeker equatorially mounted, 4 in. aperture, power about 15—$7^h\ 49^m\ 44{\cdot}08^s$.

By T. H Safford, with screen of blue tinge without a telescope—$7^h\ 50^m\ 35^s$.

At the end of the eclipse the sun was obscured by clouds. To the unwearied and skillful exertions of J. A. Whipple, we are indebted for a series of daguerreotype impressions of the progress of the eclipse, taken in the small dome of the west wing of the Observatory.

W. C. Bond, *Cambridge.*

Observations were made at Burlington, N. J., with a 5 feet equatorial telescope, and from the very favorable state of the weather were quite satisfactory; beginning $7^h\ 31^m\ 54^s$, and ending $9^h\ 5^m\ 32^s$. Latitude of the observatory 40° 4′ 51″·6. Saml. J. Gummere.

4. *Science of Pisa.*—Pisa is a fine city, and its university contains the best general collection in zoology, geology, mineralogy and botany in all Italy. It is justly celebrated at home for the high character of its scientific men, and deserves to be generally applauded for their sakes. Chas. Matteucci,—the two Savi, sons of the renowned G. Savi,

Professor of botany at Pisa until his death,—Joseph Meneghini professor of mineralogy and geology,—Piria, the chemist, are all names of just celebrity, and we found them most agreeable and enthusiastic men. Prof. Meneghini is a young man and has held his office only two years in place of his unfortunate predecessor Prof. Pila, who was shot in one of the republican battles of 1848. He is also a zoologist and botanist, and has edited "Observazione Postume di Zoologia Adriatica del Prof. Stefano Andrea Renier, Venezia, 1847, containing 16 plates in folio, principally occupied with figures of sponges."—*Correspond. of B.S., Jr.*

5. *Fish of Mt. Bolca.*—At Padua we found the most complete collection of the fossil fish of Mt. Bolca, probably in the world; over 500 specimens, generally presenting both sides, some of them five or six feet long, and all remarkably perfect. We visited this celebrated locality last Friday. It is in a very wild and romantic region, surrounded by lofty mountains. Mt. Bolca itself is 2000 feet high; and to the north and east, the Tyrolese Alps rise abruptly, leaving a profound and steep valley between them and the base of Bolca. Columnar basalt in regular forms crowns the summit and intrudes between the vertical fish-beds.—*Correspondence of B. Silliman, Jr., dated Milan, June* 30, 1851.

6. *The Werner Festival at Freyberg*, (Architect; from the Athenæum, June 21, No. 1234.)—The memory of the great founder of geology is becoming dearer to his numerous disciples every year. Thus, the late commemorative festival was very numerously attended. After the procession had been formed in the halls of the Mining Academy, it proceeded by torchlight to the ancient cathedral. Passing the venerable piles of the huge cloister, it arrived at the monument of Werner, richly decorated; and by the portal of Byzantine origin entered the wide halls of the church. Prof. Breithaupt, as senior of the professors, delivered an oration in honor of the man whose pupils are now spread over the whole globe. The procession was then joined by 700 miners, attired in their mediæval costume. When Werner became professor in Freyberg, it was exclusively a Saxon institution; but, under him it embraced, besides 981 natives, 700 foreigners, and amongst them 236 not Germans, and 33 pupils from all parts of the globe—some among them now occupying the highest rank in the mining profession.

7. *Monticelli's collection of Minerals at Naples for sale.*—This collection, now in the hands of a nephew of the late Monticelli, the distinguished Italian mineralogist, is offered for sale. It contains 4000 specimens. There are over 400 Vesuvian specimens, containing the largest and finest suite of Vesuvian species and varieties extant, all thoroughly labelled. Besides these, it includes also a beautiful series of Elba and Sicilian minerals, and a general collection rich in the species of the most celebrated European localities. Farther information may be had by applying to the editors of this Journal.

8. *Correction.*—The following note has been received for publication from B. A. Gould, Jr.—Prof. Airy has most kindly called my attention to an important error in the publication of my Report on the Velocity of the Galvanic Current in Telegraph Wires, and which is due solely to my own inadvertence. On page 92 of the Proceedings of the American Association at their New Haven meeting; page 156 of the last volume of your Journal, and page 20 of the extract in pam-

phlet form, the tables for the St. Louis and the Louisville signals have been mutually interchanged. The correctness of the published results is however not affected, as the error occurred during the preparation of the manuscript for the press.

9. *Letters from Christiania* announce that the Swedish government is fitting out an Expedition for the circumnavigation of the world.

OBITUARY.

Sir JAMES GRAHAM DALYELL, the eminent naturalist, and President of the Society for Promoting the Useful Arts in Scotland, died in Edinburgh, on the 7th June, at the age of seventy-seven.

VI. BIBLIOGRAPHY.

1. *Reports of the Secretary of War, with Reconnaissances of Routes from San Antonio to El Paso;* by Brevet Lt. Col. J. E. JOHNSTON, Lieut. W. F. SMITH, Lieut. F. T. BRYAN, Lieut. N. H. MICHLER, and Capt. S. G. FRENCH of the Quartermaster's Department. Also the Report of Capt. R. B. MARCY's *Route from Fort Smith to Santa Fe;* and the Report of Lieut. J. H. SIMPSON, *of an Expedition into the Navajo Country;* and the Report of Lieut. W. H. C. WHITING's *Reconnaissances of the Western Frontier of Texas.* Senate Ex. Doc. No. 64, 31st Congress, 1st Session; 250 pp. 8vo. Washington, 1850.—Like other reports from officers under the Bureau of Topographical Engineers, of which Col. J. J. Abert is at the head, these Reports contain many observations of interest to science, and especially to the Geological and Ethnographic departments. The volume is illustrated by 75 lithographic plates and maps, the former containing views of scenery, of Trap dykes and other geological phenomena, of both individual natives and groups in their sports, of ancient hyeroglyphical inscriptions, and numerous other subjects of interest. We reserve further notice for a future number.

2. *The Banker's Magazine and Statistical Register*, edited by J. SMITH HOMANS, Esq. Published at Boston in monthly Nos. of 84 pages, at $5 per year.—Under the editorship of Mr. Homans, the Banker's Magazine is a work of general learning and research, and of wide and philosophical views with regard to moneyed relations and institutions at home and abroad. It also contains much detailed information respecting the production of the precious metals in different countries as well as their circulation, besides facts and opinons on various collateral topics.

The August number, among its many excellent articles, contains a sketch of the early history of banking, with a variety of details which render the magazine of the first importance to bankers, and to well informed merchants.

The publisher of this able periodical gives notice that the following important and interesting works will be embodied in the volume for the year beginning July 1851, and ending June 1852:—1. New varieties of gold and silver coins and bullion, with important details relating to the coinage, rules of the Mint, &c.; by Jacob R. Eckfeldt and W. E. Dubois, Assayers of the U. S. Mint. 2. The American Law of Banking, a synopsis of the decisions of the higher courts of every State in

the Union upon the subjects of banking, bills of exchange, promissory notes, damages of bills, usury, notaries public, &c.; the decisions of each State will be arranged by themselves commencing with Maine, to be followed in order by New Hampshire, Vermont, Massachusetts, Connecticut, New York, &c. 3. History of Banking and Currency, by W. J. Lawson, Esq.; a recent English work. 4. Historical sketches of the Early Currency among the American Colonies. 5. Gilbart's practical Treatise on Banking, *concluded*. The second American edition of this work entire (470 pp.) may be had of booksellers throughout the United States.

3. *A Guide to the Scientific Knowledge of Things Familiar;* by Rev. Dr. BREWER. From the London edition. 426 pp. 16mo. New York. 1851. C. S. Francis and Co.—This work consists of questions and answers on familiar applications of science and the various physical phenomena of every day life. The questions are such as naturally arise in the mind of a person of ordinary observation; and the work gives simple yet sufficient explanations. The reader will gather a great amount of information from this little volume, and will find it ready to solve many doubts and queries that are suggested by operations in nature around him.

4. *Elements of Latin Pronunciation, for the use of Students in Language, Law, Medicine, Zoology, Botany, and the Sciences generally, in which Latin words are used;* by S. S. HALDEMAN, A.M., Prof. Nat. Hist. Univ. Penn. 76 pp. 12mo. Philadelphia, 1851.—Prof. Haldeman through extensive intercourse with the Indians of this continent and the natives of many other regions, has studied with great success the science of phonetics, and has thus prepared himself for his researches into the true pronunciation of the Latin language. The work therefore commends itself to scholars not only as a treatise on this particular language, but also for its classification of sounds, and for general views on their force, modes of combination, and relations.

5. *The Fourth Annual Report of the Board of Regents of the Smithsonian Institution;* showing the operations, expenditures and condition of the Institution during the year 1849. Washington, 1850.—Besides the other topics of this important report, it contains a detailed descriptive and historical catalogue of the various libraries of the country, made out by Mr. C. C. Jewett, the very able Librarian of the Institution.

6. *Ausführliches Handbuch der Analytischen Chemie*, von HEINRICH ROSE. In two volumes; the first of 968 pages 8vo on Qualitative Analysis, and the second of 1070 pages, on Quantitative Analysis. Braunschweig, 1851.—The Analytical Chemistry of Rose is so well known and so highly appreciated, that we need only announce here that a new edition has appeared in Germany, greatly enlarged. It is the most learned work extant on the subject and the most convenient for the student.

7. *The Journal of Agriculture*, a monthly of 32 pages, edited by WM. S. KING and J. J. MAPES. Boston. The first number of this new Agricultural Journal appeared on the 2nd of July last.

8. *Iconographic Encyclopedia.*—No. 21 of this valuable work published by Rudolph Garrigue, New York, has been issued. The plates sustain the high character promised by the earlier numbers.

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Dr. Charles Robin: Rapport a la Société de Biologie par la commission chargée d'examiner les communications de M. Souleyet, relatives à la question désignée sous le nom de Phlébentérisme. 132 pp. 8vo. *Paris.* 1851. J. B. Baillière.

Proceedings of the Acad. Nat. Sci. Philadelphia, vol. v.—APRIL. p. 170. Note on the Palæotherium Proutii; *J. Leidy.*—p. 171. On the bones of a Reptile supposed to be from the new red sandstone, in the S. E. corner of Lehigh county, Pa.; *I. Lea.*—pp. 172, 173. New Fossil Tortoises, (*Stylemys nebrascensis*, Leidy, *Testudo lata*, L., and *Emys hemispherica*,) from Nebraska Territory; *J. Leidy.*—p. 173. On the paucity of half caste children in New Holland; Dr. *Morton.*—p. 175. On some Caprimulgidæ in the collections of the Academy; *J. Cassin.*—MAY. p. 201 and 212. On the transferring of a portion of tissue of a scirrhous mamma from a female to a frog; *J. Leidy.*—p. 201. On the plants affording gamboge and camphor; Rev. *F. Mason.*—p. 204. A Gryllotalpa americana destroyed by the growth of a Fungus; *J. Leidy.*—p. 205 and p. 224. Contributions to Helminthology; *J. Leidy.*—p. 213. On the Habits of Birds of Western Texas, and descriptions of undescribed species; *Col. G. A. McCall.*

Proc. Bost. Soc. Nat. Hist. JAN., 1851.—p. 1. Remarks on the "Aztec children;" Dr. *J. M. Warren.*—p. 2. New Fossil Echinoderms from the Lower Tertiary of Georgia; *T. T. Bouvé.*—p. 5. New Holothuria of the coast of the United States; *W. O. Ayres.* (New genus Sclerodactyla proposed.)—p. 7. Two new shells of Massachusetts Bay, Spirialis Gouldii, Thracia Couthouyi, and a new Holothuria, Anaperus unisemita; *Wm. Stimpson.*—p. 9. List of fossils of the Post-pliocene of Chelsea; *Wm. Stimpson.*—p. 10. Observation on the shell and sternum of the Trionyx ferox; *J. Wyman.*—FEBRUARY. p. 11. New species of Synapta; *W. O. Ayres.*—p. 12. Species of shells new to Massachusetts Bay; *Wm. Stimpson*, (includes the new species, Rissoa eburnea, R. multilineata, R. Mighelsii, R. exarata, R. pelagica, Turritella acicula, T. areolata, Chemnitzia modesta, C. interrupta, C. seminuda.)

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APPENDIX.

The American Association for the Advancement of Science.—The annual meeting of the Association, for 1851, was held at Albany, N. Y., during the week commencing Monday, August 18th. Prof. Agassiz was President of the meeting. The attendance was unusually large, and upwards of 120 papers were presented. The department of Geology and that of Astronomy and Physics were most largely represented, while Zoology received comparatively little attention. The address of Prof. A. D. Bache, President of the year past, was delivered Wednesday evening: it was an able and instructive discourse on the circumstances attending the organization of the Association, its progress, and the direction in which to look for its greatest usefulness.

One of the most important points brought out in the astronomical department, was a new Lunar formula by Mr. Longstreth, containing a correction, according to which an error hitherto disregarded, is eliminated, and a perfect coincidence with observation is obtained. Prof. Mitchel's improved method of observing right ascension and N. P. distance was reported upon by a committee in terms of the highest commendation. In geology, the Taconic system was brought up by Prof. Emmons, and the claims urged for it were ably set aside in remarks by Prof. W. B. Rogers in a paper on the geological features of Western Vermont and Massachusetts, and also by facts brought forward by Prof. J. Hall, Mr. J. W. Foster, and others. In zoology, Prof. Agassiz presented a paper on a new mode of alternate generation, showing that the bulbs of the Tubulariæ are proper Medusæ, remaining attached to the animal and giving out true ova. We must reserve farther remark to our next number.

The Association was treated with the highest liberality by the citizens of Albany, and at the close of the meeting, it was announced that the city would defray the expenses of publishing the volume of Proceedings. By invitation from the city of Troy, there was an excursion to that city on Thursday, where a session was held at the Rensselaer Institute, after which the members were shown to a handsome collation.

Prof. Peirce, of Harvard, was chosen President for the next year. The meeting will be held at Cleveland, Ohio, on the 3d Wednesday in August, 1852, this city having invited the Association and generously offered to publish the Proceedings at the city expense. A similar invitation and offer were received from Brooklyn; but that from Cleveland was of prior date. A semi-annual session was not appointed.

We give below the titles of the papers presented. We would solicit information from members as to any omissions, which we will correct in our next number.

1. Astronomy, Physics, Mathematics.

On the Origin of the Forms, and the present condition of the Cluster of Stars and Resolvable Nebulæ; by Prof. S. Alexander, of Princeton.

On the Atmospheric Envelopes of Venus and other Planets; by the same.

Account of a Meteor seen on the night of Oct. 3, 1850; by Prof. Brocklesby.

On the Solar Eclipse of July 28; by Lieut. Davis, U. S. N.

Additional observations on the tides at Cat Island; by Prof. A. D. Bache, Superintendent of the U. S. Coast Survey.

Notes on the Tides at Sand Key, near Key West; by the same.

On some phenomena bearing on Electrical Theory; by Prof. Joseph Henry.

On Electrical Theory; by Dr. Robert Hare, of Philadelphia.

On a Meteorological Report of Prof. Espy; by the same.

On a problem in the Doctrine of Chances; by Prof. B. Peirce, of Harvard.

An account of Longstreth's Lunar formula; by the same.

On the relation between the square roots of Negative quantities in Algebra and the principles of Perpendicularity in Geometry; by John Paterson, of Albany.

On Daltonism or Blindness to particular Colors; by Prof. McCulloh, of Princeton.

Case of the Tertiary Rainbow; by Charles Hartwell.

On Special Analogies in the Phenomena presented by the two Senses of Sight and Touch; by Prof. S. Alexander, of Princeton.

On the relation between Erect Vision and the Inverted Image of the Retina; by Prof. W. W. Clark, of Albany.

On the Solar Light; by D. VAUGHAN, of Cincinnati.

Daguerreotypes of the late Solar Eclipse, and of Spots on the Sun; by DAVID A. WELLS, of Cambridge.

The bearing of some recent Microscopical results upon the present Theories of Light; by Dr. W. J. BURNETT, of Boston.

On the Zodiacal Light; by Prof. D. OLMSTED, of Yale College.

On deep Sea Soundings; by Lieut. M. F. MAURY, U. S. N.

Observations on the Eclipse of the Sun, July 28th, 1851; by Prof. PHILIP TEN EYCK, of Albany.

Experimental Researches, tending towards an Improvement in the Telescope, by Prof. ALEXANDER C. TWINING, of New Haven.

Results of a set of Observations in repetition of Foucault's Experiments; made at Providence, R. I., by Profs. CARSWELL and NORTON.

On the Pendulum Experiment; by Prof. J. D. DANA, of Yale College.

The Pendulum at Bunker Hill Monument; by Prof. E. N. HORSFORD, of Harvard.

The Effect of Heat on the Perpendicularity of Bunker Hill Monument; by the same.

On the use of air as a medium for conveying mechanical Power; by Lieut. E. B. HUNT.

On the Proper Measure of Mechanical Force; by Prof. J. H. C. COFFIN, of Lafayette College.

The occurrence of placid water in the midst of large areas where waves are constantly breaking; by Prof. HORSFORD.

2. METEOROLOGY.

On the distribution of rain for the month of September; by Prof. E. LOOMIS.

On the Clouds and Equatorial Cloud-rings of the Earth; by Lieut. MAURY, U. S. N., Superintendent of the Washington Observatory.

On Ocean Temperatures; by the same.

A Comparison of the Diurnal Law of the Mean Irregular Fluctuation of the Magnetical Elements at the stations of Observation in North America; by Capt. LEFROY, of the Toronto Observatory.

On the Influence of Terrestrial Electricity on Climates; by D. VAUGHAN.

On the Quantity of Rain at different heights, from observations made at the Institution for the Deaf and Dumb; by Professor MORRIS, of New York.

Temperature at Hartford, Connecticut, with a Map; by Professor BROCKLESBY.

On the Meteorological Observations of New York, from 1825 to 1850; by Dr. FRANKLIN B. HOUGH, of New York.

On the Progress of the System of Meteorological Observations conducted by the Smithsonian Institute, and the propriety of an immediate extension of it throughout the American Continent; by Prof. E. GUYOT, of Cambridge.

3. CHEMISTRY.

Relation of the Chemical Constitution of Bodies to Sight; by Prof. E. N. HORSFORD, of Harvard.

Solidification of the rocks of Florida Reef; by the same.

On the permeability of Metals to Mercury; by the same.

Plasticity of Phosphorus; by the same.

Note on Ammonia in the Atmosphere; by the same.

On the existence of organic matter in Stalactites and Stalagmites, containing Crystallized and Amorphous Crenate of Lime; by D. A. WELLS, Cambridge.

On a New Method for the Analysis of Soils; by the same.

On the Soils of Pike county, Scioto valley, Ohio; by the same.

On the Value of Soil Analysis, and the points to which special attention should be directed; by Prof. JOHN P. NORTON, Yale College.

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No. 14 12 10 9 7 5		
Ea. 50 35 20 15 12 10		
Crucibles, black lead various sizes, pr No.....	..	04
Cupels, French,		
No. 1 2 3 4 5 6 7 8 9 10		
Pr Doz. 30 30 38 45 75 1,20 2,40 3,50 5,40 7,00		
Cylinders Flint Glass,		
High. 7 in. 8 in. 9 in.		
30 40 50		
Dippers Porcelain, French with cover lip and wooden handle,		
Diam. in. 9 8 7 6 5 4 3½ 3		
Ea. 2,50 2,00 1,25 1,12 85 70 50 40		
Desiccating Apparatus, by sulphuric acid, consisting of ground glass plate, bell glass, and porcelain acid saucer, ...from	2 a 3	50
Desiccating Apparatus, Liebig's, consisting of copper water bath, drying tube, chloride of calcium tube, aspirator connecting tubes, &c	10	00
Evaporating Dishes, Berlin porcelain, with lip, glazed inside and out,		
No. 000 00 0 1 2 3 4 5 6 7		
Ea. 10 15 20 25 25 30 35 45 55 75		
No. 8 9 10 11		
Ea. 1,00 1,50 2,50 3,00		
Evaporating Dishes, Dresden porcelain,		
Diam. in. 17 15½ 14½ 12½ 11½ 10½		
No. 000 00 0 1 2 3		
Ea. 5,50 5,00 3,60 2,50 1,80 1,50		
Diam. in. 9½ 8 7½ 6 5½ 5 4 3		
No. 4 5 6 7 8 9 10 11		
Ea. 1,25 90 65 50 40 35 20 18		
Evaporating Dishes, French porcelain, thin,		
Diam. in. 1 2 3 4 4¾ 5½ 7 8½		
Ea. 8 15 21 35 42 60 75 90		
Evaporating Dishes, French Glass, in setts of 9,	2	75
Filters, paper, cut round, ready for use, of French and German gray paper.		
In. diam. 3 4 5 6 8 10 12 15½ 20 22		
Pr. hund. 22 35 45 60 85 1,00 1,00 1,10 1,20 1,30		
Filtering Paper, French gray, ...pr. r'm,	4	00
" " " white, made from pure material, without being bleached by chlorine, ...per ream,	8	00
do do .....per quire,	..	50
Filtering Paper, Swedish,..... " "	1	25
Filtering Stands, hard wood, ...	1	00
" " polished,.....	1	25
Flasks, French, long neck and rim at top, flat bottom,		
Oz. 2 4 8 16 32 64		
Ea. 10 12 15 22 30 50		
Flasks, round bottom, with rim,		
Oz. 2 4 16 32		
10 12 22 30		
Flasks, German glass, ground rim, flat bottom,		
Oz. 1 2 4 6 8 12		
15 18 25 28 30 35		
Flasks, spreading rim, German glass,		
Oz. 1 2 3 4 6 8 12		
Ea. 10 15 18 22 28 30 35		
Funnels, Glass, for filtering, French,		
qt. pt. ½pt. 4oz. 3oz. 1oz. ½oz. ¼oz.		
Ea. 31 22 15 10 10 8 8 8		
Funnels, tube,.....each,	..	25
" wedgewood,		
No. 2 2½ 3 3½ 4 4½ 5 5½ 6 7 8 9		
15 18 25 30 38 42 48 60 72 90 1,20 1,50		
Furnace, sheet iron, Liebig, for organic analysis,.....	2	25
Furnace, wrought iron, Berlin make, with dome and hood, &c. for crucible and retort,	18	00
Hydrometers, Ether,.....	..	75
" Alcohol,.....	..	75
" Acid, ...	1	00
" Cases, containing Thermometer, three decimal hydrometers and cylinder..	12	00

	Dolls	Cts.
Lamps, spirit, French glass, No. 3	..	70
" " " " " 2	..	60
" " " " " 1,	..	50
" " " without foot, 38 & 50,		
" Spirit, German, vase form.		
No. 1 2 3 4		
40 50 65 75		
" brass, Rose pattern, with porcelain foot,	6	50
" " " with mahogany foot,	5	50
" brass, Luhme pat'n on 3 feet, l'ge size,	6	50
" brass, Luhme pattern small size,	6	00
Lamp Wicks, for the above pr doz.	..	12
" Stands,	1	50
Litmus Paper, blue and red, pr sheet,	..	06
Measures, graduated,		
Oz. 1 2 3 4 6 8 12 16		
Ea. 30 35 40 50 60 70 90 1,20		
Mercury Troughs, Berlin porcelain, ea	2	00
Microscopes, pocket, 1 lens, "	1	25
" " 2 " "	1	75
" " 3 " "	2	50
Minim Glasses, "	..	35
Mortars, wedgewood,		
No. 0000 000 00 0 1 2 3 4 5 6		
Diam. 2¾in. 3 3½ 4 4½ 5 5½ 6 6½ 7		
Each, 44 50 58 64 72 80 88 1,00 1,10 1,25		
No. 7 8 9 10 11		
Diam. 7½ 8½ 10 11 12		
Each, 1,62 2,00 2,50 3,25 3,75		
Mortars, iron, tinned inside,		
No. 1 2 3 4 5 6 7 8 9 10 12		
Ea 50 56 60 75 95 1,15 1,35 1,68 2,40 2,65 4.00		
Mortars, glass,		
Diam. in. 2½ 3¼ 3¾ 4 4½ 5 6		
Ea. 38 60 83 90 1,05 120 1,75		
Mortars, agate,		
Diam. in. 1 7 8 2 2¼ 2 3-8 2½ 3		
Ea. 3,25 3,50 4,00 4,25 5,25 6,25		
Muffles, "Beaufaye,"		
In. 4x3 5x3½ 5½x4 6x5 7½x6		
Ea. 30 45 60 75 1,20		
Nitrogen Apparatus, Liebig, consisting of 24 inch furnace, combustion tube, graduated tube, porcelain trough, &c.	12	00
Pipettes, 25 a 37½c		
Platina, capsules, pr grain,	..	03
" Crucibles, " "	..	03
" Foil, " "	..	02½
" Wire,	..	02½
Precipitating Glasses, conical and Phillips, in sets of six, pr set,	1	50
Reduction Tubes, 1 bulb, each,	..	31
" " 2 " "	..	38
Retorts, plain French,		
Oz. 2 4 16 32		
Ea. 10 12½ 23 28		
Retorts, tubulated French,		
Oz. 1 2 4 8 16 32 64 gall.		
Ea. 30 30 31 37 50 62 81 1,10		
Receivers, tubulated,		
Oz. 4 8 16 32 ½gall. gall.		
35 42 48 55 81 1,10		
Retort Holders, gay luisac, polished,	1	50
" " " plain,	1	00
Retort Holders, upright, polished,		
Inches, 15 12 10		
1,50 1,25 1,00		

	Dolls	Cts.
Retort Holders, upright plain,		
Inches, 15 12 10		
1,25 1,00 88		
Rods Glass, white, pr lb.	..	3
" " colored, "	..	
" " enamelled, "	1	
Safety Tubes, without bulb,	..	37½
" " with bulb,	..	62½
Sand Bath, wrought iron,		
Diam. in. 2 2½ 3 3½ 4 4½		
Ea. ,20 ,25 ,31 ,38 ,45 ,50		
Scales, French, on stand for weighing grains,	6 a 8	00
Spatulas, steel, wood handle,		
In. 3 4 5 6		
Ea. 15 20 25 35		
Specific Gravity Bottles, in cases,		
100 to 200 grains,	2	00
500 to 1,000 "	2	50
Specific Gravity Bottles, in cases,		
1,000 grains, with case and counterpoise,	3	50
1,000 grains with case and counterpoise, and 1,000 gr. wt.	4	00
20 gramme, perforated stoppers, in case,	2	00
25 " " " "	2	50
50 " " " "	2	75
Still, Copper, Berlin make, 8x12in with block tin helm, very superior finish,	28	00
Stirrers, per doz. 3 to 12 in. 25 a 50c	..	..
Straw Rings, each,	..	6
Saucers, acid, porcelain, "	1	00
Test Glasses, French, wine glass form with lip,		
No. 1 2 3 4		
Doz. 1,20 1,38 1,50 1,80		
Test Tubes, Bohemian glass,		
Inches, 3 4 5 6		
Pr. doz. 35 40 55 60		
Test Tube Stands,		
mahogany, for 19 tubes,	1	25
" " 13 "	..	75
white wood, for 19 tubes,	..	75
" " 13 "	..	50
Thermometers, German, scale engr'd on stem, 280° c	3	50
do do do 350° c	4	50
Thermometers, French scale, engraved on stem, 580° F.	4	50
do 310° F.	4	00
Tongs, crucible, analytical, 6in. long iron, bent,	..	75
" " " 6in. polished steel,	1	25
" " " " d'ble,	1	50
" " platina points,	4	75
Touch Bottles, for sol. cobalt, &c. each,	..	25
Tripods, brass,	..	75
" iron,	..	50
Tubing Glass, French, ass'td, pr lb.	..	45
" " Bohemian, ass'd, "	..	75
" " " soft ass'd, "	..	75
" " " Barometer for apparatus, pr lb.	..	75
Tubes, graduated, cubic centim 60,	1	50
" " " " 100	2	00
Tubes, chloride calcium, each,	..	25
Watch Glasses, Bohemian, small, pr doz.	..	
" " " nests of 3, pr nest,	..	
" " " " 4, "	..	
Woulfes Bottles,		
8oz. pt. qt. ½gall. gall.		
50 62½ 75 1,20 2,38		

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Plate II

ZODIACAL LIGHT

AT THE VERNAL EQUINOX LAT 41°18′

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXXI.—*Observations on the Zodiacal Light; with an inquiry into its Nature and Constitution, and its Relations to the Solar System;* by Denison Olmsted, Professor of Natural Philosophy and Astronomy, in Yale College.

Read before the American Association for the Advancement of Science, at the Annual Meeting at Albany, August, 1851.

I submit to the Association a series of observations on the Zodiacal Light, made by me at Yale College from 1833 to 1839, upon the basis of which I propose to offer a new description of this mysterious phenomenon, and a brief inquiry into its nature and constitution, and its relations to the solar system. Particularly, I propose to inquire whether or not it is the origin of the meteoric showers of November and August.

Various circumstances conspire to interrupt the continuity of a series of observations on the zodiacal light; among which are the following:—

1. The comparatively few nights in the year when, in our climate, the sky is cloudless, and the atmosphere sufficiently clear to afford good observations on a light so feeble and diffuse.

2. The low angle which the zodiacal light makes with the horizon for the greater part of the year while it is visible.

3. The presence of the moon, which entirely effaces it; and, occasionally, for long periods, the presence of Venus or Jupiter, and sometimes of both planets. The light of Venus, especially, is often so bright, and the planet is so situated in the midst of the zodiacal light, as greatly to interfere with observations. Hence, a

number of years are necessary of diligent attention to the phenomena of this light, in order to become well acquainted with its habitudes and laws. Nor can I pretend to have made the best possible use of the opportunities afforded for viewing it, during the six years that my attention was directed to it. On the contrary, my observations were often interrupted by ill health, and other causes beyond my control. Still, they were sufficient to convince me that my previous knowledge of this body was exceedingly defective, and my notions of it very erroneous; and the same may justly be said of most or all of the descriptions and graphic representations of it given in works of science.

I will therefore, first, attempt an accurate *description* and *representation* of the zodiacal light.

Since the direction of this body is oblique to the circles of diurnal revolution, and since it appears only immediately before or immediately after the sun, and therefore more or less of it falls within the twilight, consequently, its appearances are very different in different latitudes, being seen best of all in the tropical regions, where its direction always makes a high angle with the horizon, and where the twilight is short; and being scarcely visible in such high latitudes as London and Edinburgh, except near the time of the equinoxes. Hence British writers who have attempted a description of it, have usually given one that is altogether vague and inaccurate. The lower latitude of our place of observation (41° 18′ 30″) affords a much better view of it, and my description and representation of it will conform to its appearance at this latitude.

I learn from my friend, Prof. Dana, that while with the Exploring Expedition in the torrid zone, he seldom failed of seeing the zodiacal light morning or evening, when not prevented by some of the causes before enumerated; but during the summer months in our climate, we hardly see it at all. At the beginning of autumn we look for it in the morning sky, and at the end of autumn in the evening sky. The state of the atmosphere most favorable for seeing it at its minimum intensity, is that peculiarly transparent condition which either precedes or follows a copious rain. The presence of a black cloud, also, near the horizon, frequently enables us, by contrast, to see more distinctly the faint diffusive light of the upper portions. With these advantages we may unite that of fixing one eye on a darker portion of the heavens a few degrees to the right or left, and looking askance with the other eye over the region of the object sought. This last expedient will usually be found useful for fixing its exact boundaries, in its various stages of intensity.

Although, as was first remarked by Mr. E. C. Herrick, faint traces of the zodiacal light may be seen in the northeast early in August, yet it will hardly be obvious to common observation be-

fore the latter part of September. I quote from my record for September 25th, 1835:—

Observed the zodiacal light from 3 to 4½ o'clock, A. M. Very faint. Seen only by fixing the right eye on the region of Canis Major, and carrying the left eye along the ecliptic. Covers Regulus and the cluster in Cancer, and terminates a little south of Castor.

The earliest distinct view I have obtained of this body in the *evening* sky, was on the 21st of November, 1837, when I have the following record:—

Have constantly searched for the zodiacal light in the evening since the 13th inst. Imagined that that part of the milky way where this light would cross it was more luminous than common, but the light is ambiguous on account of the presence of Venus. But this evening examined in company with three of my astronomical pupils, all distinguished for acuteness of vision. At 7 o'clock, Venus being near the horizon and hid behind a cloud, we could severally define the boundaries of the zodiacal light. By fixing the right eye on the milky way near Altair, and the left eye near the head of Capricornus, we could discern a pyramid less bright than the milky way, but still sufficiently distinct to be sure of its presence. Its upper edge grazed α and μ Capricorni and β Aquarii, its vertex reaching to the right shoulder of Aquarius. Light very feeble and diffuse, but the triangular space between it and the milky way, embracing the Dolphin, perceptibly darker. Elongation from the sun 90°.

As a description of the zodiacal sufficient to guide the observer I will offer the following: From the middle of September until the latter part of November, he will confine his attention to the *morning* sky. An hour and a half before daybreak (which is at that season of the year, in our climate, about 4 o'clock,) he will first discern a feeble, diffuse, and scarcely visible light, of a pyramidal figure, extending from the horizon upward through the zodiac to Gemini, covering Regulus and Presepe, and terminating a little south of Castor. Near the horizon its material is usually mixed up with the vapors that prevail there, so as to prevent its forming a definite boundary at its base; but from an altitude of a few degrees above the horizon, the light gradually declines until it fades into nonentity. Along the central part of the pyramid the illumination is greater than at the borders. From the greater length and amplitude revealed to us by circumstances peculiarly favorable for observation, we have reason to think that, on ordinary occasions, we do not see the whole of the body, but that it really extends further than its visible boundaries, both in length and breadth. If the observer continues to watch this body from the middle of September onward through the month of October to the middle of November, he will perceive that the vertex or visible terminus moves along through the order of the signs, and nearly at the same rate with the sun, appearing, on the

25th of October, to occupy the space south of Denebola in the tail of the Lion, terminating a little above Regulus. From this time until the middle of November it appears nearly stationary, ascending from the horizon to the constellation Leo, in some part of which it terminates, the vertex varying somewhat in altitude with the condition of the sky. After the 13th of November, the light fades in the morning sky, contracts in dimensions, and soon becomes stationary and then retrograde with respect to the sun, proceeding eastward no further than γ Virginis, a point which it reaches by the 26th of November, having at this time an elongation of only 60°, whereas a fortnight before the elongation was 90°. As the sun advances in the ecliptic, while the light appears nearly stationary, the elongation on this side continues to diminish, as well as the dimensions and the illumination, until early in January, after which it is scarcely seen in the east until August.

The foregoing general statements are supported by observations taken at different times through the period of six years before mentioned, a few of which I extract from my records:—

Nov. 26, 1837.—This morning about daybreak, saw the zodiacal light—very bright and distinct, but elongation only 60°.

Nov. 28.—Commenced observations at 5 o'clock. Zodiacal light brighter than usual in preceding years at this season, but the vertex appears nearly stationary in Gamma Virginis.

Dec. 5.—Zodiacal light visible this morning as early as 3 o'clock. Not quite so bright as on the 28th of November, but increased in brightness from 3 o'clock till daybreak—vertex still in γ Virginis.

Dec. 9.—Examined the eastern sky from 4^h 30^m till daybreak. Very cold and clear. Zodiacal light much less bright than on the 5th. Width also less; when I first went out could scarcely see it. Became distinct by 5 o'clock, half an hour before daybreak. Yet much feebler than it was ten days ago. Contracted between Spica and Theta Virginis, 4° north of Spica, whereas a few days since the border grazed this star.

Jan. 18, 1837.—Zodiacal light very diffusive and ill-defined. Seen after this no more in the east.

We will now introduce the observer to the western sky. Here the zodiacal light first comes into view, so as to be distinctly defined, about the 21st of November, at which time it lies far in the southwest, crosses the milky way, the head of Capricornus, and has its vertex near the right shoulder of Aquarius, with an elongation from the sun of full 90°. From this time it climbs rapidly upwards, until by December 2d it reaches nearly to Algenib in the equinoctial colure, having an elongation of more than 100°. By about Christmas the vertex reaches almost to Alpha Arietis, having an elongation of towards 120°. It becomes nearly stationary through the month of January, but in

February and March it moves slowly onward through Taurus to Gemini, beyond which it scarcely advances. The accompanying diagram (Pl. II,) is intended to represent the general appearance of the zodiacal light, when seen under favorable circumstances near the time of the vernal equinox. It is seen of a pyramidal form with a broad base resting on the horizon. Its northern border grazes the bright star Algenib in Pegasus, passes south of Alpha Arietis seven or eight degrees, and about two degrees south of the Pleiades. Along its southern boundary we recognize the stars in the mouth and neck of the Whale, and still higher, Aldebaran, the Hyades, and the horns of the Bull. The successive positions attributed to the zodiacal light from the time of its earliest appearance in the western sky, the 21st of November, to the vernal equinox, are not absolutely uniform, but they still correspond to observations made during the six years before mentioned, as will appear from a few extracts from my record book. I have already recited the observation of November 21st, 1837, when the return of the body to the western sky was first recognized.

Nov. 26, 1837.—Light feeble, Venus being very bright; but seen after Venus was set, reaching nearly to the Fish south of Pegasus. Elongation 100°.

Dec. 2.—New moon begins to interfere with observations; but this evening the zodiacal light was visible after the moon was set. Covers the Pentagon in Pisces and reaches beyond it. Elongation 110°.

Dec. 18.—Early part of the day a violent rain and high wind. Cleared off towards night. Zodiacal light very bright, reaching at least to Alpha Arietis—nearly as bright as the milky way. Elongation 120°.

It ought to be remarked that the phemonena of this body were peculiarly striking in the autumn and winter of 1837, and the observations made this year show a greater intensity of light and a greater elongation from the sun than those of corresponding dates in 1835 and 1836.

Dec. 21, 1835.—This evening atmosphere very transparent. Zodiacal light very conspicuous, reaching nearly to Algenib, though quite faint towards the vertex. Elongation 90°.

Dec. 28, 1837.—Night favorable. Appeared to me not to reach quite so far eastward as it did a few nights since—certainly not beyond the equinoctial colure. Could not be certain much further than the pentagon of stars in Pisces. Elongation 75°.

February 7.—Zodiacal light very conspicuous since the last moon, but has advanced eastward very little since Christmas, still reaching only to Alpha Arietis. Elongation 75°.

Feb. 24.—First night since the moon has been away. Sky favorable for observation. Zodiacal light bright and well defined, its axis nearly in the ecliptic. Reaches to the space between Aldebaran and the Pleiades. Elongation 85°.

March 26.—Zodiacal light very bright, reaching above the Pleiades, which are a little north of the axis. Elongation 60°.

March 29.—Light more faint. Elongation 60°. Vertex near the ecliptic.

April 6.—Light fading rapidly. Very diffuse.

May 1.—Last night a very plentiful rain after a series of warm days. To-day air keen and sky very clear. This evening zodiacal light remarkably distinct, (for this season of the year,) being discernable much nearer the horizon than common, and reaching further eastward among the stars than I ever observed it before, namely, into the neighborhood of Castor and Pollux. Elongation 60°, but presumed to be much greater than it would be but for the extraordinary transparency of the atmosphere.

May 10, 1834.—Zodiacal light seen for ten minutes after twilight ceased—say till ten minutes after nine. Reached to Castor, but very diffuse. Elongation 57°.

Seen no more in the west till the latter part of November.

To present at one view the various elongations from the sun, observed from Nov. 21st to May 10th, the result is as follows:—

1. Nov. 21st,	Elongation,	90°	7. Feb. 7th,	Elongation,	75°
2. Nov. 26th,	"	100°	8. March 29th,	"	60°
3. Dec. 2d,	"	110°	9. April 6th,	Light rapidly fading.	
4. Dec. 18th,	"	120°	10. May 1st,	Elongation,	60°
5. Dec. 21st,	"	90°	11. May 10th,	"	57°
6. Dec. 28th,	"	75°			

From this tabular view it appears that when the body first came into view, on the 21st of November, it extended about 90° eastward of the sun; that its elongation increased rapidly from this period, being five days afterwards 100°, in six days more 110°, and in fourteen days after this 120°, which is the greatest elongation I have ever noticed; and being at the same time about 60° westward of the sun, its whole extent in longitude was 180°.

I have, in a few instances, remarked what was apparently a sudden and remarkable expansion of the zodiacal light, a circumstance more than once noted by Cassini. My record for November 21st, 1838, is as follows:—

At 5 A. M., about 20 minutes before twilight, the zodiacal light was very large, extending in breadth from Corvus to Arcturus. Never saw it so broad before. More inclined towards the south than usual, its vertex passing one or two degrees to the south of Regulus.

Whether this extraordinary enlargement in breadth, implying a space of more than 40° was owing to a change in the body itself, or to some unusual atmospheric refraction, or the accidental presence of an aurora borealis, it is impossible for me to decide.

It is well known that the great French astronomer, Dominique Cassini, was the first to direct the attention of astronomers towards the zodiacal light, and that he made numerous observations on it extending from 1683 to 1688 inclusive, which are pub-

lished in the eighth volume of the Memoires of the French Academy, together with observations on the same phenomenon made at Geneva by a friend of his, M. Fatio. An elaborate digest of these records are made by Mairan in his celebrated Treatise on the Aurora Borealis, including also a few observations of his own, and of several other philosophers. It is interesting to compare these ancient observations with such as we have been able to make at corresponding times of the year; and having made this comparison in numerous instances, I feel able to say that *the zodiacal light, in the main, is the same thing that it was in the days of Cassini and Mairan,* being subject to similar variations at different seasons of the year and in different states of the atmosphere. I shall avail myself of such aid as I can obtain from this and every other source in the remaining parts of this essay.

NATURE AND CONSTITUTION OF THE ZODIACAL LIGHT.

1. *Length.*—The extreme portions of this body sometimes extend beyond the earth's orbit. It is obvious that, at an elongation of 90°, it must reach a tangent drawn to the earth's orbit at the place of the spectator; and if it reaches beyond that tangent, as is sometimes the case, it must of course extend beyond the earth's path. According to one of our observations, on the 18th December, 1837, its elongation was 120°.

The variable apparent elongation to which this phenomenon is subject is more or less influenced by three causes: the state of the atmosphere, the inclination of its line of direction to the horizon, and the length of the twilight. In order to eliminate the effect due to atmospheric changes we require numerous series of observations, continued through successive years, and, if possible, instituted at long intervals of time. The mean of such an assemblage of observations would exhibit results nearly free from the effects of accidental variations in the transparency of the atmosphere. Since the axis of the zodiacal light does not deviate far from the ecliptic, we may imagine it to be represented by a portion of that circle on the artificial globe, and we shall easily see that since its inclination to the horizon varies between twenty-five and seventy-two degrees, being twenty-five at the vernal equinox, (twenty-five degrees with the eastern and seventy-two degrees with the western horizon,) this cause must greatly affect the degree of intensity of the zodiacal light. The same must obviously be the case with the variations in the length of twilight, being an hour and a half after sunset at the vernal equinox, and two hours and a quarter after sunset at the summer solstice. But were these causes, combined, the only or the chief reason why the apparent elongation of the zodiacal light from the sun is greater at one time than at another, then, since at the vernal equinox the elevation above the horizon is at its maximum and

the duration of twilight at its minimum, the apparent elongation ought to be greatest of all; whereas it is then only 60°, while from the 21st of November to the 18th of December, 1837, we found it increase from 90° to 120°, and this at a season of the year when the elevation above the southern horizon is near its minimum, and the duration of twilight is longer than before. Nor is this an anomalous fact; the elongation has uniformly appeared greater in the west, during the months of December and January, than during March and April. Again, at the winter solstice the elevation is much greater in the morning than in the evening; but the light is far more conspicuous in the west than in the east.

2. *Direction.*—The general direction of the zodiacal light is, as its name imports, from the sun along the zodiac. Cassini and Mairan thought that its axis lay nearly or quite in the plane of the solar equator, making an angle with the ecliptic of seven and a quarter degrees; and, accordingly, that its nodes must be in the part of the ecliptic which the earth traverses in June and November. But Cassini himself remarked, that the direction of the axis is not always the same. On several occasions the vertex appeared to him to veer to the northward of its previous direction, so that, while it would at one time just *graze* Alpha Arietis on its northern border, shortly afterwards that star would be wholly within it. Before I had met with these statements in Cassini, I had several times remarked the same changes in the direction of the axis, the vertex sometimes lying in the ecliptic itself. Nor, as I think, will the observations warrant the conclusion that the axis of this body cuts the sun and consequently lies across the ecliptic in the plane of a great circle. On the 19th of January, 1835, the northern border was 8° south of Castor, and the vertex directed to a point south of the Pleiades. Consequently, its axis could not have been far from the ecliptic. But, on the 20th of March, the vertex reached above the Pleiades, and the axis had perceptibly veered northward from the ecliptic. These observations taken in connection with those of Cassini, indicate that the supposed relation of this body to the solar equator is not constant. In the year 1843, M. Houzeau published an article in the Astronomische Nachrichten in which he investigated the plane of symmetry of the zodiacal light from data derived from a comparison and digest of all the observations he could collect. He makes the inclination less than half that of the solar equator, and the place of the nodes of course quite different from that assigned to them by Cassini.

If then, as is demonstrated by Houzeau, the normal place of the axis gives it an inclination of only about $3\frac{1}{2}°$, the great occasional deviations from this direction confirm our remark, that the course of the zodiacal light along the zodiac is not always the same but is subject to vary with the seasons of the year.

3. *Motions.*—The zodiacal light sometimes moves forward in the order of the signs, it is sometimes stationary among the stars, and sometimes retrograde. Beginning with morning observations in August, and noting its positions from day to day, we see it first stretching across the middle of the constellation of the Twins.* The vertex moves slowly along through the constellations Gemini, Cancer, and Leo, being, on the 13th of November, a little east of Gamma Leonis,† having, in three months shifted its place eastward nearly three signs, and consequently nearly kept pace with the sun in its annual revolution, maintaining an average elongation from that body of 90 degrees. After the middle of November its light fades away in the east, its vertex becomes nearly stationary and of course its elongation westward of the sun diminishes, until the early part of January, when it is hardly visible at all in the morning sky. In the mean time, this light has been rapidly rising in the evening sky, and to this we will next direct our attention.

We have seen that about the 25th of November its upper portions reach beyond Capricornus, its vertex extending to the right arm of Aquarius. From this time it moves onward, sometimes more rapidly than the sun, but with an average elongation of 90°, until about the 24th of February, when it reaches a point a little south of the Pleiades. From the latter part of February, its progress eastward has seemed to me slower than before, hardly gaining one sign for the next three months, scarcely ever being distinctly visible beyond Castor, although neither the want of elevation above the southern horizon, nor the length of the twilight, would prevent its being seen beyond this if in reality it existed there. Finally, early in April it rapidly fades away, and soon after the first of May disappears altogether.

These facts respecting the zodiacal light are derived chiefly from my own observations, made and recorded at different times during the six years following 1833; but on comparing them with the observations of Cassini made towards 170 years ago, a near correspondence will be found between them; and the same will be the case if the comparison be made with the tabular view of observations collected from various authorities, as given by Houzeau in 1843.

In some cases, the apparent progress of this body through the signs corresponds so nearly to that of the sun, as to suggest the idea that it is something attached to the sun, and has an apparent motion due to the same cause, namely, the motion of the earth in its orbit. In other cases, however, its movements are too sudden and too unlike those of the sun to permit such a conclusion.

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* Above this point the light is blended with that of the milky way.

† Cassini placed it in 1686 at χ Leonis.

At one time, as we have seen, its elongation from the sun increases rapidly from 90° to 120°; at other times it becomes for considerable periods stationary among the stars, and even retrograde; facts which seem to imply motions of its own independent of the sun and the earth; and such motions in any body thus situated, though they might be greatly modified by perspective, can hardly be any other than motions of revolution. On this subject La Place has the following remarks, at the end of his chapter "on the figure of the atmosphere of the sun."

(1.) "This atmosphere can extend no further than to the orbit of a planet, whose periodical revolution is performed in the same time as the sun's rotary motion about its axis, or in twenty-five days and a half. Therefore, it does not extend so far as the orbits of Mercury and Venus, and we know that the zodiacal light extends much beyond them.

(2.) "The ratio of the polar to the equatorial diameter of the solar atmosphere, cannot be less than two-thirds, and the zodiacal light appears under the form of a very flat lens, the apex of which is in the plane of the solar equator. Therefore, the fluid which reflects to us the zodiacal light, is not the atmosphere of the sun, and since it surrounds that body, it must revolve about it according to the same laws as the planets: perhaps this is the reason why its resistance to their motions is insensible."

4. *Material.*—The matter of which the zodiacal light is composed, presents many analogies to that of comets. In its visible form, in its direction with respect to the sun, in its very shade and color, in its increasing density towards the sun, in its transparency which, as in comets, is such as to permit small stars to be seen through almost every part of it: in all these respects we recognize a great resemblance between the zodiacal light and the tails of comets. We are at least authorized to say that it is a "nebulous body."

From all the foregoing considerations on the nature and constitution of the zodiacal light, we infer, then, that it is a nebulous body, revolving around the sun in an orbit but slightly inclined to the ecliptic.

I proposed finally to inquire *whether or not the zodiacal light is the origin of the meteoric showers of November and August, and especially those of November.*

It may be known to some present that after the great meteoric shower of November 13th, 1833, I published in the American Journal of Science some observations on the phenomena and causes of that remarkable exhibition of shooting stars, in which I came to the conclusion that they proceeded from a nebulous body revolving about the sun, and, at its aphelion, approaching very near to that part of the earth's orbit through which the earth passes on the 13th of November. At the conclusion of the

essay, I suggested the possibility that the zodiacal light might be the body in question. I was reluctant, however, to insist on such a connection, because the existence of the nebulous body was inferred from evidence wholly independent of the zodiacal light, and even before the zodiacal light was thought of. In fact, at that time I had very vague ideas respecting this light, as something that appears in the west after twilight about the time of the vernal equinox, but I did not even know that it was ever visible at the period of the year when the November meteors occurred; for at that time I had never read either the observations of Cassini on this body, or the treatise of Mairan on the Aurora Borealis, where so much is ascribed to its agency in the production of this latter phenomenon. Nearly twenty years have since elapsed, and I have had sufficient opportunity to observe the zodiacal light, and to reflect on the question of its possible connection with the meteoric showers of November and August. The result is, an increasing conviction of such a connection. I may here remark that the first idea of such an origin of the November meteors, is now generally ascribed by European writers to M. Biot. It may be proper, however, to state that the paper in which M. Biot first mentions the subject, is an essay read before the French Academy soon after the meteoric shower of November, 1836, three years after my paper was published. M. Biot does, indeed, favor the idea that these showers of meteors have their origin in the zodiacal light; but in noticing the views which I had published, respecting the cause of the meteoric shower, which he did me the honor to review at some length and in a manner very encouraging to myself, he distinctly stated that I had in my paper suggested the idea that the zodiacal light might possibly be the very nebulous body in question.

I am aware that the opinions I have formed differ widely from those entertained by many members of this Association, whose eminent talents and great success in the investigation of truth entitle them to the highest deference; but, should I fail of convincing them of the correctness of my views, I still indulge the hope that I may secure increased attention to a natural phenomenon, which appears to me to have important relations to our solar system, as well as to several of the most sublime and mysterious phenomena of nature.

In the paper which I published in the American Journal of Science in the year 1834, on the cause of the great meteoric shower of November 13th, 1833, I inferred the existence, in the planetary spaces, of a nebulous body revolving around the sun, the extreme portions of which on the 13th of November lay over or across the earth's orbit, in such a manner that the earth passed through it, or at least near enough to it to attract portions of it into its atmosphere, where they took fire and exhibited the

phenomena of shooting stars. As the leading steps by which I arrived at this conclusion, after an extensive induction of facts, were very brief and simple, I may be permitted to repeat them here. I argued thus: If all the meteors which fell on this occasion (which were in vast numbers, and some of them proved to be bodies of comparatively large size,) had been restored to their original position in space, they would of themselves have composed a nebulous body of considerable extent. But, since the same shower had been several times repeated without any apparent exhaustion of the nebulous body, it was inferred that only small portions of that body came down to us, such as constituted its extreme parts which approximated nearest to the earth; and various reasons induced the belief that the nebulous body itself was one of very great extent. It was a striking fact that the earth had, during several preceding years, fallen in with this body at exactly the same part of its orbit. Now, since it is impossible to suppose that a body thus situated, and consequently subject to the sun's attraction, could have remained at rest in that part of the earth's orbit while the earth was making its revolution around the sun, the conclusion was that the nebulous body itself has a revolution around the sun, and a period of its own. Since the earth and the body met for several successive years at the same point of the ecliptic, that period must obviously be either a year or less than a year. It could not be more than a year, for, in that case, the body would not have completed its revolution so as to meet the earth at the same point for successive years. Its period might be a year, and it might be less than a year provided the time was some aliquot part of a year, so as to make it revolve just twice or three times, &c., while the earth revolves once. The time being given we easily find the major axis of the orbit by Kepler's third law. On trying so short a period as one third of a year, it gives a major axis too short to reach from the sun to the earth, and hence it was inferred that the body could not have so short a period as four months, since it would never in that case reach the earth's orbit, even at its aphelion. A period of six months was found to be sufficient, and this was accordingly assumed at first to be the time, although the possibility that the period might be a year was distinctly admitted. But, extensive as I even then believed the nebulous body to be, I had formed very inadequate notions of its real extent, for this may clearly be sufficient to reach from the sun to the earth, and thus to correspond in dimensions to the zodiacal light; and since the center of gravity of this body may be far within the earth's orbit, so its orbit may, even at its aphelion, be distant from the earth, and yet the extreme portions of the body may reach beyond the ecliptic. It would, therefore, be entirely consistent with my original views, to assign to a nebulous body of such an extent as

that of the zodiacal light, a period as short as one third of a year, or even less.

I do not assert positively that the zodiacal light is the veritable body which produces the meteoric showers of November and August. Before such an hypothesis can be proved to be true or false, with certainty, a greater number of precise observations continued through a series of years, would require to be made, and a careful comparison instituted between the hypothesis and the facts. Should the zodiacal light be found at last incompetent to explain the periodical meteors, the existence of a nebulous body, as inferred from a full survey of the facts in the case of the meteoric shower of November 13th, 1833, independently of all hypothesis, will still be true. But, with great deference, I submit to the Association, the following *presumptions* in favor of the opinion that the zodiacal light is the nebulous body which produces the meteoric showers of November.

1. The zodiacal light, as we have found in our inquiry into its nature and constitution, is a *nebulous body.*

2. It has a *revolution* around the sun.

3. It reaches beyond and *lies over the earth's orbit*, at the time of the November meteors, and makes but a small angle with the ecliptic.

4. Like the "nebulous body," its periodic time is *commensurable* with that of the earth, so as to perform a certain whole number of revolutions while the earth performs one, and thus to complete the cycle in one year, at the end of which the zodiacal light and the earth return to the same relative position in space. This necessarily follows from the fact that at the same season of the year it occupies the same position one year with another, and the same now as when Cassini made his observations nearly one hundred and seventy years ago.*

5. In the meteoric showers of November, *the meteors are actually seen to come from the extreme portions of the zodiacal light*, or rather a little beyond the visible portions; and the same was true of the radiant point of the meteors, (when watched, as it was by Mr. Fitch,† from Oct. 16th to Nov. 13th, 1837,) namely, that the radiant always keeps the same relative position with respect to the vertex of the zodiacal light, being with that vertex in Gemini, in the month of October, and travelling along with it through the Constellation Cancer, and into Leo, where it was on the morning of the meteoric shower. Observations, so far as they have been made, indicate a similar relation between the meteors of August and the extreme portions of the zodiacal light.

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* For the first suggestion of this analogy, I am indebted to one of my former pupils, Mr. Hubert Newton.

† Amer. Jour, Sci., xxxiii, 386.

These five propositions I offer as so many *facts* established by observation. Most of them appear in the original paper of Cassini on the zodiacal light; others may be seen in the tabular collection by Houzeau of all the known observations made at different periods; a few, not noted by others, have been added by myself. For the inferences here made respecting the connexion of this body with the periodical meteors, I alone am responsible.

Art. XXXII.—*Cultivation of Nutmegs and Cloves in Bencoolen;** by Dr. Lumsdaine.

The mode of culture adopted in the different nutmeg plantations is nearly the same. The beds of the trees are kept free from grass and noxious weeds by the hoe, and the plough is occasionally run along the interjacent spaces for the purpose of eradicating the Lallang (Andropogon caricosum) which proves greatly obstructive to the operations of agriculture. The trees are generally manured with cow dung and burnt earth once a year in the rainy season, but the preparation of suitable composts and their mode of application are but imperfectly understood. The pruning knife is too sparingly used; very few of the planters lop off the lower verticels of the nutmeg trees or thin them of the unproductive and straggling branches.

The site of a plantation is an object of primary importance, and doubtless the alluvial grounds are entitled to preference from the acknowledged fertility of their soil, and its appropriate organization and capability of retaining moisture, independent of the advantage of water carriage. Several of the nutmeg trees of the importation of 1798 at Moco Moco, are placed in soil of this description; although never manured they are in the highest state of luxuriance and bear abundantly; and I have been informed by a gentleman recently arrived from that station, that the stem of one of them measures 38 inches in circumference. Some of the trees in my own experimental garden, corroborate the truth of this assertion; one of these blossomed at the early age of two years ten months and a half, a degree of precocity ascribable solely to its proximity to the lake which forms the southern boundary. This was the first tree that blossomed of the importation of 1803, which consisted of upwards of 22,000 nutmeg plants. Next to the alluvial deposits, virgin forest lands claim pre-eminence, their surface being clothed with a dark colored carbonized mould, formed by the slow decay of falling leaves and

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* From a Paper in the Proceedings of the Agricultural Society established in Sumatra in 1820; cited from the Journ. of the Indian Archipelago and Eastern Asia, v, p. 78, Jan., 1851.

mouldering trunks of trees; and next to these are to be ranked the open plains. Declivities are objectionable from the risk of the precipitation of the mould and manure into the subjacent ravines, by the heavy torrents of rain that occasionally deluge the country. Above all, the plantation must be protected from the southerly and northerly winds by a skirting of lofty trees, and if nature has not already made this provision, no time should be lost in belting the grounds with a double row of the Cassuarina littorea and Cerbera manghas, which are well adapted for this purpose. This precautionary measure will not only secure the planter against eventual loss from the falling off of the blossom and young fruit in heavy gales, but will prevent the up-rooting of the trees, a contingency to which they are liable from the slender hold ther roots have in the soil. If the plantation is extensive, subsidary rows of these trees may be planted at convenient distances. No large trees whatever should be suffered to grow among the spice trees, for these exclude the vivifying rays of the sun and arrest the descent of the salutary night dews, both of which are essential to the quality and quantity of the produce. They further rob the soil of its fecundity, and intermingle their roots with those of the spice trees. It is true that by the protection they afford they prevent frequently the premature bursting of the husk, occasioned by the sudden action of a hot sun upon it when saturated with rain; but the loss sustained in this way is not equal to the damage the spice trees suffer from these intruders. Extensive tracts of land are to be met with in the interior of the country, well adapted for the cultivation of the nutmegs and cloves, and to these undoubted preference is due.

In originating a nutmeg plantation, the first care of the cultivator is to select ripe nuts, and to set them at the distance of a foot apart in a rich soil, merely covering them very lightly with mould. They are to be protected from the heat of the sun, occasionally weeded, and watered in dry weather every other day. The seedlings may be expected to appear in from 30 to 60 days, and when four feet high, the healthiest and most luxuriant, consisting of three or four verticels, are to be removed in the commencement of the rains to the plantation, previously cleared of trees and underwood by burning and grubbing up their roots, and placed in holes dug for their reception, at the distance of eighty feet from each other, screening them from the heat of the sun and violence of the winds. It is a matter of essential importance that the ground be well opened and its cohesion broken, in order to admit of the free expansion of the roots of the tender plants, and that it be intimately mixed with earth and cow manure, in the proportion of two-thirds of the former to one-third of the latter. The plants are to be set in rows as well for the sake of regularity as for the more convenient traversing of the plough, which is

now to be employed in clearing the intermediate spaces of lallang and other noxious grasses, carefully avoiding to trespass on the beds of the trees. They must be watered every other day in sultry weather, manured annually during the rains with four garden baskets full of the above mentioned compost to each tree, and protected from the sun until they attain the age of five years. They will now be sufficiently hardy to bear the sun, and from that age until their fifteenth year, the compost should consist of equal parts of cow dung and burnt earth, and from eight to twelve baskets full will be required for each bearing tree, a lesser proportion being distributed to the males. From the power of habit the trees will, after the fifteenth year, require a more stimulating nutriment; the dung ought not, therefore, to be more than two or three months old, and the mixture should consist of two parts of it to one of burnt earth, of which the suitable proportion will be from twelve to sixteen baskets to each tree biennially. In all cases the prepared compost must be spread out in the sun for three or four days previous to its application, in order to destroy grubs and worms that may have lodged in it, and which might injure the roots of the plants.

In all plantations, whether situated in forest land or in the plains, the necessity of manuring at stated intervals has been found indispensable, and is indeed identified with their prosperity. The proper mode of applying it is in a circular furrow in immediate contact with the extremeties of the fibrous roots, which may be called the absorbents of the plant. Where there is a scarcity of dung, recourse may be had to the dregs remaining after the preparation of the oil from the fruit of the Arachis Hypogæa, which in mixture with burnt earth, is a very stimulating manure; or composts may be formed from the decomposition of leaves or vegetable matter of any description. A very fertilizing and highly animalized liquid nutriment for plants, is obtained by macerating human ordure in water in proper pits for four or five months, and applying the fluid to the radical absorbents of the plants. Seaweed and many other articles may also be resorted to, which will readily occur to the intelligent agriculturist.

During the progressive growth of the plantation, the beds of the trees are to be regularly weeded and the roots kept properly covered with the mould, for these have a constant tendency to seek the surface; the growth of the lateral branches alone is to be encouraged, and all suckers, or dead and unproductive branches, are to be removed by the pruning knife, so as to thin the trees considerably and to admit of the descent of the night dews, which are greatly contributive to their well being, especially during the dry and sultry weather; creepers are to be dislodged, and the lower verticels lopped off, with the view of establishing an unimpeded circulation of air. The conclusion of the great

annual harvest is the fittest time for pruning the trees. After the eradication of the lallang, the growth of innoxious grasses is to be encouraged in the intervals between the trees, which will give the plantation the appearance of a park, and the plough is now to be abandoned.

The nutmeg tree is monœcious as well as diœcious, but no means of discovering the sexes before the period of inflorescence are yet known. The relative proportion of male and female trees to each other is also undefined, and is indeed the result of chance. Setting aside however all pretension to mathematical precision, the number of productive trees may be roundly estimated at two-thirds of the whole cultivation. As the monœcious plants are productive, the number of male trees necessary to be retained will depend entirely on that of the monœcious kind; all above this number, being considered superfluous, should be cut down and other trees planted in their stead. Were I indeed to originate a nutmeg plantation now, I should either attempt to procure grafts on male stocks on such trees as produce the largest and best fruit, by the process of inarching, notwithstanding the speculative hypothesis of the graft partaking of the gradual and progressive decay of the parent tree, leaving a branch or two of the stock for the purpose of establishing a regular polygamy, by which means the plantation would consist of monœcious trees only; or I should place the young plants in the nursery at the distance of four feet from each other, and force them to an early discovery of their sex, by lifting them out of their beds once a year and replacing them in the same spot, so as to check the growth of wood and viviparous branches. The sex might thus be ascertained on an average within the fourth year, and the trees removed to the plantation and systematically arranged, whereas in the usual mode of proceeding it is not ascertainable in general before the seventh year.

Upon an average, the nutmeg tree fruits at the age of seven years, and increases in produce till the fifteenth year, when it is at its greatest productiveness. It is said to continue prolific for seventy or eighty years in the Moluccas, but our experience carries us no farther than twenty-two and a half years, all the trees of which age that have been properly managed, are still in the highest degree of vigor and fecundity; and for this reason no term for planting a succession of trees can as yet be fixed upon. Seven months in general elapse between the appearance of the blossom and ripening of the fruit, and the produce of one bearing tree with another under good cultivation may, in the fifteenth year of the plantation, be calculated at five pounds of nutmegs, and a pound and a quarter of mace. I have observed, however, that some trees produce every year a great quantity of fruit, whilst others constantly give very little. It bears all the year round, but more plentifully in some months than in others. The

great harvest may generally be looked for in the months of September, October, November and December, and a small one in April, May and June. Like other fruit trees on this portion of Sumatra, I have remarked that it yields most abundantly every other year. The fruit having ripened, the outer integument bursts spontaneously, and is gathered by means of a hook attached to a long stick, and the mace being cautiously stripped off and flattened by the hands in single layers, is placed on mats for three or four days in the sun to dry. Some planters cut off the heels and dry the mace in double blades, from an opinion that the insect is apt to breed in or about the heels, and that the double blade gives a better and more substantial appearance to the mace. The former idea is entirely groundless, for if the article be properly cured, kept in tight packages in a dry situation, and exposed to the sun for five or six hours once a fortnight, there need be no apprehension of the insect; and if it is not, it will assuredly be attacked by it whether the heels be cut off or not; again, the insect is much more likely to nestle within the fold of the double blade, and the fancied superiority of appearance has so little weight with the purchaser, as not to counterbalance the risk of probable deterioration and eventual loss. In damp and rainy weather the mace should be dried by the heat of a charcoal fire, carefully conducted so as not to smoke it or blacken its surface.

The nuts liberated from their macy envelope are transported to the drying house, and deposited on the elevated stage of split neebongs, placed at a sufficient distance from each other to admit of the heat from a smouldering fire beneath without suffering even the smallest nuts to pass through. The heat should not exceed 140° of Fahrenheit, for a sudden inordinate degree of heat dries up the kernels of the nuts too rapidly, and its continued application produces fissures in them, or a fermentation is excited in them which increases their volume so greatly as to fill up the whole cavity of the shell, and to prevent them from rattling when put to this criterion of due preparation. The fire is lighted in the night. The smoking house is a brick building of a suitable size, with a terraced roof, and the stage is placed at an elevation of ten feet from the ground, having three divisions in it for the produce of different months. The nuts must be turned every second or third day that they may all partake equally of the heat, and such as have undergone the smoking process for the period of two complete months and rattle freely in the shell, are to be cracked with wooden mallets, the worm-eaten and shriveled ones thrown out, and the good ones rubbed over simply with recently prepared well sifted dry lime. They are now to be regarbled, and finally packed for transportation in tight casks, the insides of which have been smoked, cleaned, and covered with a coating of fresh water and lime. If packed in chests, the seams must be dammered to

prevent the admission of air or water. There is no necessity for sorting them, as previously to their sale they are classed into sizes in the Company's warehouses in London.

The mode generally practised in preparing nutmegs for the market, is to dip them in a mixture of salt water and lime, and to spread them out on mats for four or five days in the shade to dry. I am, however, convinced from much experience that this is a pernicious practice, not only from the quantity of moisture imbibed in this process encouraging the breeding of insects and rendering the nuts liable to early decay, but from the heating quality of the mixture producing fissures and occasioning a great loss in the out turn; whereas by liming them simply in the dry way as I have recommended, the loss ought not to exceed 8 per cent. In May, 1816, I made some experiments on this subject. I cracked a quantity of nutmegs that had been smoke dried for two months, and distributed them into four equal portions. I prepared the nuts of one parcel with a mixture of lime and salt water; those of the second were rubbed over merely with fine well dried shell lime such as the natives use with their betel, although I have no doubt but that recently prepared and well sifted common lime would answer equally well; those of the third parcel were mixed, unlimed, with one-third of their weight of whole black pepper; and those of the fourth, also unlimed, with the same proportion of cloves. They were then put into separate boxes with sliding tops, and numbered 1, 2, 3 and 4, in the order I have mentioned them. At the expiration of the first year they were all sound. After that of the second, I found three worm eaten nuts in No. 1, and two in No. 3, but those in Nos. 2 and 4 remained untouched. The injured nuts were allowed to remain, and after the lapse of the third year, five worm eaten ones were discovered in No. 1, three in No. 3, and two in No. 4, those in No. 2 being in their original state. Four years and four months have now elapsed since the commencement of these experiments, and upon examining the several parcels the other day, the number of decayed nuts has not increased in Nos. 1, 3 and 4, and those in No. 2 are as good as the day they were put into the box. These experiments not only prove the superiority of liming in the dry way, but also the fact that the progress to general decay in a heap of nutmegs, even after the insect has established itself, must be a work of years. In the shell they will keep for a great length of time. I have myself kept them in this state for six years, and when cracked they were found perfectly sound. From the report of the London brokers, however, they will not answer in Europe on account of the heavy allowance for shells, which is one-third of the weight; but the Chinese merchants are in the daily habit of exporting them to Pinang and China, where they are in request. It is stated on the best authority, that unlimed or brown

nutmegs, as the home dealers call them, mixed with cloves as in experiment No. 4, are highly esteemed in England, and even preferred by some to the limed produce; most probably from the greater facility of detecting the flaws in them in their naked state.

Although the clove tree attains great perfection in the red mould of these districts, it is more partial to a less tenacious soil. Its cultivation has been established for many years in the West Indies and at Bourbon, and is of secondary importance only. The mother cloves are planted in rich mould at the distance of twelve inches from each other, screened from the sun and duly watered. They germinate within five weeks, and when four feet high are to be transplanted at intervals of thirty feet, with a small admixture of sand with the red mould so as to reduce its tenacity; and to be cultivated in the same mode as the nutmegs, only that when full grown they require less manure in the proportion of one-third. They yield generally at the age of six years, and at that of twelve are in their highest state of bearing, when the average produce may be estimated at six or seven pounds of marketable fruit each tree during the harvest, which takes place in the rainy months, but with us they have hitherto borne two crops in three years only. The fruit is terminal, and when of a reddish hue is plucked by hand, so that the process of gathering it is tedious. It is then dried for several days on mats in the sun, until it breaks easily between the fingers, and assumes a dark brown color. It loses about 60 per cent. in drying. When past its prime the clove tree has a ragged and uncombed appearance, and I am led to suppose that its existence is limited to twenty years, unless in very superior soil, in which it may drag out a protracted and unprofitable state of being to the period of perhaps twenty-four years. Hence it becomes necessary to plant a succession of seedlings when the old trees have attained eight years of age, and this octennial succession must be steadily kept in view.

With reference to the number of laborers, cattle and ploughs necessary for a plantation of 1000 nutmeg and clove trees, after the ground has been thoroughly cleared of underwood and stumps of trees, I consider that seven Chinese or active Bengalee laborers, fifty head of cattle and two ploughs, would be sufficient for all the purposes of the cultivation, with the exception of collecting the clove harvest, which, being a very tedious process, would require an extra number of hands; and indeed the best plan would be to gather it in by contract.

Art. XXXIII.—*On Coral Reefs and Islands;* by James D. Dana.—Part Fourth.

From the Report on Geology of the Exploring Expedition under Capt. Wilkes, U.S.N.

Formation of Reefs, and Causes of their Features and Geographical Distribution.

An inquiry into the causes and origin of the features presented by coral reefs and islands, has led us to glance at the nature of coral zoophytes, and at the effects of various agents upon their development. The way has thus been prepared for considering the bearing of these facts, and of other influencing causes, on the growth of the coral plantation as a whole. While, therefore, the preceding pages treat of zoophytes as individual species, the following will relate to those results which proceed from their accumulation, and the causes which have determined the features and geographical distribution of reefs and islands.

1. *Formation of Reefs.*

Very erroneous ideas prevail, respecting the appearance of a bed or area of growing corals. The submerged reef is often thought of as an extended mass of coral, alive uniformly over its upper surface, and, by this living growth, gradually enlarging upward: and such preconceived views, when ascertained to be erroneous by observation, have sometimes led to skepticism with regard to the zoophytic origin of the reef-rock. Nothing is wider from the truth: and this must have been inferred from the descriptions already given. Another glance at the coral plantation should be taken by the reader, before proceeding with the explanations which follow.

Coral plantation and coral field, are more appropriate appellations than coral garden, and convey a juster impression of the surface of a growing reef. Like a spot of wild land, covered in some parts with varied shrubbery, in other parts bearing only occasional tufts of vegetation over barren plains of sand, here a clump of saplings, and there a carpet of variously colored flowers —such is the coral plantation. Numerous kinds of zoophytes grow scattered over the surface, like vegetation upon the land: there are large areas that bear nothing, and others that are thickly overgrown. There is, however, no green sward to the landscape; sand and fragments fill up the bare intervals between the flowering tufts: or where the zoophytes are crowded, there are deep holes among the stony stems and folia.

These observations will prepare the mind for some disappointment in a first view of coral reefs. Nature does not make greenhouses, but distributes widely her beauties, and leaves it for man

to gather into gardens the choicer varieties. Yet there are scenes in the coral landscape, which justify the brightest coloring of the poet: where coral shrubbery and living flowers are mingled in profusion; where Astræa domes appear like the gemmed temples of the coral world, and Madrepore vases, the decorations of the groves; and as the forests and flowers of land have their birds and butterflies, so

"——— Life in rare and beautiful forms
Is sporting amid those bowers of stone,"

for fish of various hues, red, blue, purple, green, and other brilliant shades, keep constant play, appearing and disappearing among the branches.

These fields of growing coral spread over submarine lands, such as the shores of islands and continents, where the depth is not greater than their habits require, just as vegetation extends itself through regions that are congenial. The germ or ovule, which, when first produced, swims free, finds afterwards a point of rock or dead coral to plant itself upon, and thence springs the tree, or some other form of coral growth.

The analogy to vegetation does not stop here. It is well known that the debris of the forest, decaying leaves and stems, and animal remains, add to the soil; and that accumulations of this kind are ceaselessly in progress: that by this means, in the luxuriant swamp, deep beds of peaty earth are formed. So it is in the coral mead. Accumulations of fragments and sand from the coral zoophytes, and of shells and other relics of organic life, are in constant progress; and thus a bed of coral debris is formed and compacted. There is this difference, that a large part of the vegetable material consists of elements which escape as gases on decomposition, whereas coral is itself an enduring rock-material undergoing no change except the mechanical one of comminution. The animal portion is but a mere fraction of the whole zoophyte.

In these few hints, we have the whole theory of reef-making: not a speculative opinion, but a legitimate deduction from a few simple facts, and bearing close analogy to operations on land. The coral debris and shells fill up the intervals between the coral patches, and the cavities among the living tufts, and in this manner produce the reef deposit, which is finally consolidated while still beneath the water.

The coral-zoophyte is especially adapted for such a mode of reef accumulation. Were the nourishment drawn from below, as in most plants, the solidifying coral rock would soon destroy all life: instead of this, the tree is gradually dying below while growing above; and the accumulations cover only the dead portions. Moreover, to prevent accident, where these accumulations do not keep pace with the progress of death, organic incrustations cover the lifeless trunk, and protect it from the dissolving waters.

But on land, there is the decay of the year and that of old age producing vegetable debris; and storms prostrate forests. And are there corresponding effects among the groves of the sea? It has been shown that coral plantations, from which reefs proceed, do not grow in the "calm and still" depths of the ocean. They are to be found amid the very waves, and extend but little below a hundred feet, which is far within the reach of the sea's heavier commotions.* Here is an agent which is not without its effects. The enormous masses of uptorn rock found on many of the islands may give some idea of the force of the lifting wave; and there are examples on record, to be found in various Treatises on Geology, of still more surprising effects.†

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* During the more violent gales, the bottom of the sea is said, by different authors, to be disturbed to a depth of three hundred, three hundred and fifty, or even five hundred feet, and De la Beche remarks, that when the depth is fifteen fathoms, the water is very evidently discolored by the action of the waves on the sand and mud of the bottom. In the *Comptes Rendus*, t. xii, 774, M. Siau mentions that parallel ridges are formed on the bottom, by the motion of the water, which may be readily distinguished at a depth of at least twenty meters. The hollows between such ridges or zones are occupied by the heavier substances of the bottom. Similar zones were distinguished at a depth of one hundred and eighty-eight meters, to the Northwest of the St. Paul's Roads.

† Lyell, vol. ii, p. 38–40. Speaking of the force of waves on coasts, Lyell mentions the transportation of a block of stone, ninety feet from its bed, which was eight feet two inches, by seven feet, and five feet one inch in its dimensions, and another nine feet two inches, by six and a half feet, by four feet, having been "hurried up an acclivity to a distance of one hundred and fifty feet."

In an article on the subject, by Thomas Stevenson, of Edinburgh, published in the Transactions of the Royal Society of Edinburgh, (vol. xvi, 1845,) it is stated, as a deduction from two hundred and sixty-seven experiments, extending over twenty-three successive months, that the average force for Skerryvore, for five of the summer months, during the years 1843, 1844, was six hundred and eleven pounds per square foot; and for six of the winter months of the same year, it was two thousand and eighty-six pounds per square foot, or three times as great as during the summer months. During a westerly gale, at the same place, in March, 1845, a pressure of six thousand and eighty-three pounds was registered by Mr. Stevenson's dynamometer, (the name of the instrument used.) He mentions several remarkable instances of transported blocks. One of gneiss, containing five hundred and four cubic feet, was carried by the waves five feet from the place where it lay, and there became wedged so as no longer to the moved. Of the manner in which it was moved, Mr. Reid (as cited by Mr. Stevenson) says: "The sea, when I saw it striking the stone, would wholly immerse or bury it out of sight, and the run extended up to the grass line above it, making a perpendicular rise of from thirty-nine to forty feet above high water level. On the incoming waves striking the stone, we could see this monstrous mass, of upwards of forty tons weight, lean landwards, and the back-run would uplift it again with a jerk, leaving it with very little water about it, when the next incoming wave made it recline again."

Mr. Stevenson sta'es also that the Bell Rock Lighthouse in the German Ocean, though one hundred and twelve feet in height, is literally buried in foam and spray, to the very top, during ground swells, when there is no wind. On the 20th of November, 1827, the spray rose to the height of one hundred and seventeen feet above the foundations or low water mark; and deducting eleven feet for the tide that day, it leaves one hundred and six feet, which is equivalent to a pressure of *nearly three tons per square foot.*

With such facts, any incredulity respecting the power of waves should be laid aside. Moreover, it may be remarked that the Pacific is a much wider ocean than the Atlantic, with far heavier waves in its ordinary state.

We must, therefore, allow that some effect will be produced upon the coral groves. There will be trees prostrated by gales, as on land, fragments scattered, and fragmentary and sand accumulations commenced. Besides, masses of the heavier corals will be uptorn, and carried along over the coral plantation, which will destroy and grind down everything in their way. So many are the accidents of this kind to which zoophytes appear to be exposed, that we might believe they would often be exterminated, were they not singularly tenacious of life, and ready to sprout anew on any rock where they may find quiet long enough to give themselves again a firm attachment.

But it should be observed, that the sea would have far less effect upon the slender forms characterizing many zoophytes, among which the water finds free passage, than on the massive rock, against whose sides a large volume may drive unbroken. Moreover, much the greater part of the strength of the ocean is exerted near tide level, where it rises in breakers which plunge against the shores. Yet, owing to the many nooks and recesses deep among the corals, the rapidly moving waters, during the heavier swells, must produce whirling eddies of considerable force, tending to uproot or break the coral clumps. These disrupting and transporting effects, will be less and less as we recede from the shores; yet all coral depths must experience them in some degree.

There is another process going on over the coral field, somewhat analogous to vegetable decay, though still very different. Zoophytes have been described as ever dying while living. The dead portions have the surface much smoothed, or deprived of the roughening points which belong to the living coral, and the cells are sometimes half obliterated, or the delicate lamellæ worn away. This may be viewed as one source of fine coral particles; and as the process is constantly going on, it is not altogether unimportant. This material is in a fit condition to enter into solution, and it cannot be doubted that the water receives lime from this source, which is afterwards yielded to the reef.

In the Alcyonia family, which includes semi-fleshy corals, and the Gorgoniæ, the lime is often scattered through the polyps in granules; and the process of death sets these calcareous grains free, which are consequently added to the coral sands. The same process has been supposed to take place in the more common reef corals, the Madrepores and Astræas, and it is possible that this may be to some extent the case. Yet it would seem, from facts observed, that after the secretion has begun within the polyp, the secretion of lime going on takes place *against* the portions already formed and in direct union with them, and not as granules to be afterwards cemented.

The *mud-like* deposits about coral reefs have been attributed to the causes just mentioned, but without due consideration. There is an unfailing and abundant source of this kind of material in the self-triturating sands of the reefs acted upon by the moving waters. On the seaward side of the coral island, and on the shores of the larger lagoons, where the surface rises into waves of much magnitude, the finer portions are carried off, and the coarser sand remains alone to form the beaches. This is a well known fact common on all shores exposed to the waves, coral or not coral, and to this cause the sandy character is attributed. But in the smaller lagoons, where the water is only rippled by the winds, or roughened for short intervals, the trituration is of the gentlest kind possible, and, moreover, the finely pulverized material remains as part of the shores. Thus the fine material of the mud must be constantly forming on all the shores, for the sands are perpetually wearing themselves out; but the mud *accumulates* only in the more quiet waters, and within the lagoons and channels, where it settles, after being washed out from the beaches. This corresponds exactly with the facts; and every lake pool or water of our continents illustrates the same point.*

The coral world, as we thus perceive, is planted like the land with a variety of shrubs and smaller plants, and the elements and natural decay are producing gradual accumulations of material, like those of vegetation. The history of the growing reef has consequently its counterpart among the ordinary occurrences of the land about us.

The progress of the coral formation is like its commencement. The same causes continue with similar results, and the reader might easily supply the details from the facts already presented. The production of debris will necessarily continue to go on: a part will be swept by the waves, across the patch of reef, into

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* Mr. Darwin, in discussing the origin of the finer calcareous mud, (op. cit., p. 14,) supposes that it is derived, in part, from Fishes and Holothurias, and other authors have thrown out the same suggestion. He cites as a fact, on the authority of Mr. Liesk, that certain fish browse on the living zoophytes; and from Mr. Allan, of Forres, he learned also that Holothurias subsisted on them. With regard to the facts here stated, I can make no definite assertion. Small fish swarm about the branching clumps, and when disturbed, seek shelter at once among the branches, where they are safe from pursuit: I have often witnessed this fact, and never saw reason to suppose that they clustered about the coral for any other purpose. It is an undoubted fact, however, as stated by Mr. Darwin, that fragments of coral and sand may be found in the stomachs of these animals, though this is not sufficient evidence of their browsing on the coral. The conclusion deduced by him from the facts may be justly doubted. The fish and Holothurias, though numerous, are quite inadequate for the supply; and, moreover, we have, as explained above, an abundant source of the finest coral material without such aid. Motion of particle over particle, will necessarily wear to dust, even though the particles be diamonds; and this incessant grinding action about reefs, accounts satisfactorily for the deposits of coral mud, however great their extent.

the lagoon or channel beyond, while other portions lodge on its surface. But besides the small fragments, larger masses will be thrown on the reefs, by the more violent waves, and commence to raise them above the sea. The *clinker fields* of coral, by this means produced, constitute the first step in the formation of dry land. Afterwards, by farther contributions of the coarse and fine coral material, the islets are completed, and raised as far out of water as the waves can reach—that is, from six to ten feet. The Ocean is thus the architect, while the coral polyps afford the material for the structure: and when all is ready, it sows the land with seed brought from distant shores, covering it with verdure and flowers.

The growth of the reefs and islands around high lands, is the same as here described for the atoll. The reef rock in all cases is mainly a result of accumulations of coral and shell debris. There are reefs where the corals retain the position of growth, as has been described on a former page. But with these, the debris comes in to fill up the intervening spaces or cavities, and make a compact bed for consolidation. There are other parts, especially the outer reef along the line of breakers, which are formed by the gradual growth of layer upon layer of incrusting Nullipores; but in the Pacific, such formations are of small extent.*

Among the peculiarities of coral islands, the *shore platform* appears to be one of the most singular. It will be remembered that it lies but little above low tide level, and is often three hundred feet in width, with a nearly flat surface throughout.

Though apparently so peculiar, the existence of this platform is due to the simple action of the sea, and is a necessary result of this action. Passing to New Holland, from the coral islands of the tropics, we there found the same structure exemplified along the *sandstone* shores of this semi-continent, where it is continued for scores of miles. At the base of the sandstone cliff, in most places one or more hundred feet in height, there is a layer of sandstone rock, lying, like the shore platform of the coral island, near low tide level, and from fifty to one hundred and fifty yards in width. It is continuous with the bottom layer of the cliff: the rocks which once covered it, have been removed by the sea. Its outer edge is the surf-line of the shore. At low tide it is mostly a naked flat of rock, while at high tide it is wholly under water, and the sea reaches the cliff. New Zealand, at the Bay of Islands, afforded us the same fact, again, in an argillaceous sandrock; and there was no stratification in this case to favor the production of a horizontal surface; it was a direct result from the

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* Prof. Agassiz has recently observed that deposits of this last kind constitute in many places the reef rock about the Florida Keys.

causes at work. The shore shelf stands about five feet above low water. A small island in this bay is well named the "Old

"THE OLD HAT," BAY OF ISLANDS.

Hat," the platform encircling it, as shown in the above figure, forming a broad brim to a rude conical crown. The water, in these cases, has worn away the cliffs, leaving the basement untouched.

A surging wave, as it comes upon a coast, gradually rears itself on the shallowing shores; finally, the waters at top, through their greater velocity, plunge with violence upon the barrier before it. The force of the ocean's surges is therefore mostly confined to their summit waters, which add weight to superior velocity, and drive violently upon whatever obstacle is presented. The *lower* waters of the surge advance steadily but more slowly, owing to the retarding friction of the bottom; the motion they have is directly forward, and thus they act with little mechanical advantage; moreover, they gradually swell over the shores, and receive, in part, the force of the *upper* waters. The wave, after breaking, sweeps up the shore till it gradually dies away. Degradation from this source is consequently most active where the upper or plunging portion of the breaker strikes.

But, further, we observe that at low tide the sea is comparatively quiet; it is during the influx and efflux that the surges are heaviest. The action commences after the rise, is strongest from half to three-fourths tide, and then diminishes again near high tide. Moreover, the plunging part of the wave is raised considerably above the general level of the water. From these considerations, it is apparent that the line of greatest wave-action, must be above low water level. Let us suppose a tide of three feet, in which the action would probably be strongest when the tide had risen two feet out of the three; and let the height of the advancing surge be four feet:—the wave, at the time of striking, would stand, with its summit, three feet above high tide level; and from this height would plunge obliquely downward against the rock, or any obstacle before it. It is obvious, that under such circumstances, the greatest force would be felt, not far from the line of high tide, or between that line and three feet above it. In regions where the tide is higher than just supposed, as six feet for example, the same height of wave would give

nearly the same height to the line of wave action, as compared with high tide level. Under the influence of heavier waves, such as are common during storms, the line of wave-action would be at a still higher elevation, as may be readily estimated by the reader.

Besides a line of the *greatest* wave-action, we may also distinguish a height where this action is entirely null; and it is evident, from facts already stated, that the point will be found somewhat above low tide level. The lower waters of the surge, instead of causing degradation, are *accumulative* in their ordinary action, when the material exposed to them is movable: they are constantly piling up, while the upper waters are rending and preparing material to be carried off. The height at which these two operations balance one another will be the height, therefore, of the line of no degradation. As the sea at low tide is mostly quiet, and the lower of the surging waters swell on to receive the upper and parry the blow, and moreover, there is next a return current outward,—we should infer that the line would be situated more or less above low tide, according to the height of the tide, and the surges accompanying it. We are not left to conjecture on this point; for the examples presented by the shores of New Holland and New Zealand afford definite facts. Degradation has there taken place sufficient to carry off cliffs of rock, of great extent; yet below a certain level, the sea has had little or no effect. This height, at New Holland, is three feet above ordinary low tide, and at New Zealand, about five feet. With regard to the height varying with the tides, we observe that in the Paumotus, where the water rises but two or three feet, the platform is seldom over four to six inches above low tide, which is proportionally less than at New Holland and New Zealand, where the tide is six and eight feet. From these observations, it appears that the height of *no wave-action*, as regards the degradation of a coast under ordinary seas, is situated near one-fifth tide, in the Paumotus, and above half tide at New Zealand, showing a great difference between the effect of the comparatively quiet surges of the middle Pacific, and the more violent of New Zealand. Within the Bay of Islands, where the sea has not its full force, the platform, as around the "Old Hat," is but little above low water level. The exact relation of the height of the platform to the height and force of the tides remains to be determined more accurately by observation. While, therefore, the height of the shore platform depends on the tides, and the usual strength of the waves, the breadth of it will be determined by the same causes in connection with the nature of the rock-material.*

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* On basaltic shores it is not usual to find a shore platform, as the rock scarcely undergoes any degradation, except from the most violent seas; such coasts are con-

It is apparent that one single principle meets all the various cases. The rocky platform of some sea-shores, the low tide sand-spit on others, and the coral-reef platform of others, require but one explanation. The material of the coral platform is piled up by the advancing surges, and cemented through the infiltrating waters. These surges, advancing towards the edge of the shelf, swell over it before breaking, and thus throw a protection about the exposed rocks; and as the tide rises, this protection is complete. They move on, sweeping over the shelf, but only clear it of sand and fragments, which they bear to the beach.

The isolated blocks in the Paumotus which stand on the platform, attached to it below, are generally most worn one or two feet above high tide level, a fact which corresponds with the statement in a preceding paragraph with regard to the height of the greatest wave-action.

In addition to this ordinary wave-action, there are also more violent effects from storms; and these are observed alike on the Australian shores referred to, and on those of coral islands. The waters, moving through greater depths, and driving on with increased velocity up the shallowing shores among cavities or under shelving layers, break and lift the rocks of the edge of the platform, and throw them on the reef. From the observations of Mr. Stevenson, cited in a note to a preceding page, it appears that the force of the waves during the summer and winter months differs at Skerryvore more than 1200 pounds to the square foot, —in the former it averaging but 636 pounds, and in the latter 2086 pounds, while in storms it was at times equivalent to 6083 pounds. The seasons are not as unlike in the tropical part of the Pacific. Still there must be a marked difference between the ordinary seas and those during stormy weather. We have therefore no difficulty in comprehending how the ordinary wave-action should build up and keep entire the shore platform, while the more agitated seas may tear up parts of the structure formed, and bear them on to the higher parts of the island. Still more violent in action are the great earthquake-waves, which move through the very depths of the ocean.

These principles offer an explanation also of the general fact that the windward reef is the highest. The ordinary seas, both on the leeward and windward sides, are sufficient for producing coral debris and building up the reef, and in this work the two sides may go on with almost equal rate of progress: consequently we may often find no very great difference in the *width* of the

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sequently often covered with large fragments of the basaltic rocks. But on sandstone shores, this gradual action keeps the platform of nearly uniform breadth. Moreover, any uptorn masses thrown upon it, are soon destroyed by the same action, and carried off; and thus the platform is kept nearly clean of debris, even to the base of the cliff.

leeward and windward reefs, especially as the wind for some parts of the year has a course opposite to its usual direction. But seldom, except on the side to windward, is a sufficient force brought to bear upon the edge of the platform, to detach and uplift the larger coral blocks. The distance to which the waves may roll on without becoming too much weakened for the transportation of uptorn blocks, will determine the outline of the forming land. With proper data as to the force of the waves, the tides, and the soundings around, the extent of the shore platform might be made a subject of calculation.

The effect of a windward reef in diminishing the force of the sea is sometimes shown in the influence of one island on another. A striking instance of this is presented by the northernmost of the Tarawan Islands. All the islands of this group are well wooded to windward—the side fronting east, between north and south. But the north side of Tari-tari is nothing but a bare reef, through a distance of twenty miles, although the southeast reef is a continuous line of verdure. The small island of Makin, just north of Tari-tari, is the breakwater which has protected the reef referred to from the heavier seas.

Coral island accumulations have one advantage over all other shore deposits, owing to the ready agglutination of calcareous grains, as explained on a following page. It has been stated that coral sandrocks are forming along the beaches, while the reef-rock is consolidating in the water. A defence of rock against encroachment is thus produced, and is in continual progress. Moreover, the structure built amid the waves will necessarily have the form and condition best fitted for withstanding their action. The little islet of an atoll is therefore more enduring than hills of harder basaltic rocks. Reefs of zoophytic growth but "mock the leaping billows," while other lands of the same height gradually yield to the assaults of the ocean. There are cases, however, of wear from the sea, owing to some change of condition in the island, or in the currents about it, in consequence of which, parts once built up are again carried off. Moreover, those devastating seas which overleap the whole land may occasion unusual degradation from some parts. Yet these islets have within themselves the source of their own repair, and are secure from all serious injury.

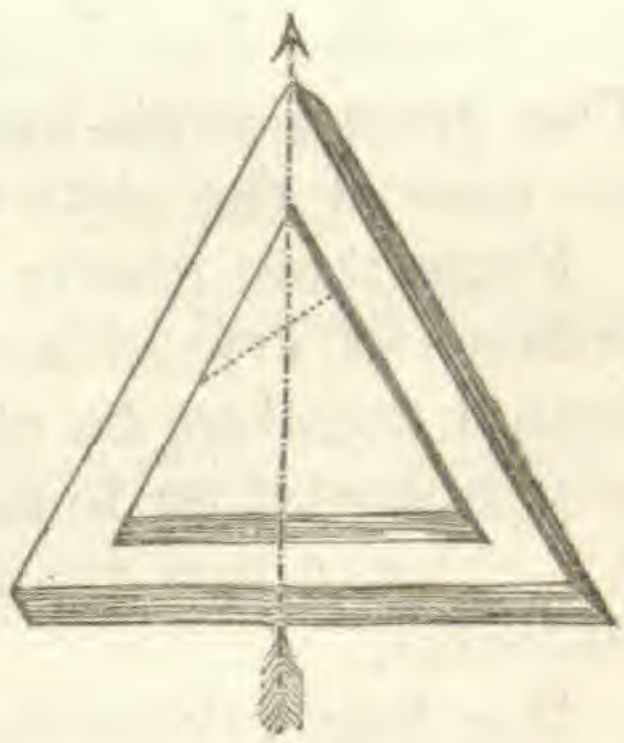
The lagoons in coral islands are constantly receiving more or less debris from the reefs; and patches of growing coral within also tend to fill them up. But the effect is slow in its progress, and none but islands of small size, as before stated, show any approximation to an obliteration of the lagoon.

Art. XXXIV.—*Optical and Blowpipe Examination of the supposed Chlorite of Chester County, Pa.;* by W. P. Blake.

Read before the American Association for the Advancement of Science, at Albany, August, 1851.

In September, 1850, Prof. B. Silliman, Jr., handed me a specimen of a beautiful green foliated mineral for optical examination; it was unexpectedly found to be biaxial; but as the locality of the specimen was not known, no further examination than the measurement of the angles was made at that time. In May, of this year, I received from Prof. J. D. Dana specimens of the hitherto supposed chlorite, of Chester Co., Pa., which I examined by polarized light, and obtained results so similar to those obtained with the specimen first referred to, as to leave no doubt of its being from the same locality.*

The mineral occurs three miles south of West Chester, in serpentine associated with magnesite, and is found in plates of irregular outline, sometimes three inches broad, and in triangular plates and tabular masses, one of which is represented in the annexed figure. These plates are equilateral triangles; and they much resemble the triangular cleavage specimens of the micas from Greenwood furnace and Monroe, N. Y. The cleavage is perfect, parallel with the broad faces of these crystals, but is not so perfect as in mica, and the laminæ are more brittle. The laminæ are flexible and elastic, but less elastic than mica. Color, beautiful emerald green. Hardness of cleavage surface, 2 to 2·25, scale of Mohs. Specific gravity 2·714, which is perhaps too low, as no specimen could be obtained perfectly free from air.



Optically it is biaxial, with a high angle, and the following are the results obtained:

Specimen *a*, examined in September, plate one decimetre long and six centimetres broad, with an irregular outline.

Specimen *b*, a triangular plate measuring one and one-fourth inches along each side, examined in May.

Apparent angle between the optic axes in *a*, 84°·30′ mean of nine measurements.

Apparent angle in *b*, 85°·59′ mean of five measurements.

The plane of the axes is perpendicular to the cleavage surface and at right angles with the base of the triangle, as indicated by the arrow in the figure. I was also able to obtain evidences of

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* Prof. Dana received his specimen from Thos. F. Seal, of Philadelphia.

optic axes in the angle of the plate opposite to the base, and found them to have an equal inclination with *b*; and the plane of these axes was found to form an angle of about 60° with the plane of the others, or to be at right angles with one of the sides of the triangle, (which is as near the angle as could be determined by marking the direction upon the plate and subsequent measurement by goniometer and protractor,) this peculiar relation of two systems of optic axes, had been noticed in *a* also, and there is probably a line of composition in most of the crystals from the locality. The position of this line is represented by the shorter dotted line in the figure.

Another interesting peculiarity is, that the optic axes are *not equally inclined to the cleavage surface*, or to a line perpendicular to it, (the "normal" of Biot.) The inclinations were measured, but as the instrument had not been adapted to this mode of measurement, the angles given can be regarded only as approximations, and are here given merely to show the existing inequality of the inclinations.

Spec. *a* gave the angles	.	.	. 50° and 34°.
" *b* " " "	.	.	. 58°·13′ and 27°·40′.

The greater angle being on the side of the "normal" adjoining the base of the plate or triangle.

From these results the mineral must be referred to one of the systems of crystallization having the three axes unequal,—and it cannot therefore be classed with the species chlorite or ripidolite, which according to authors is rhombohedral or hexagonal. The Ala chlorite was examined optically by Biot and reported to be *uniaxial*.

It is here interesting to observe that we have this undoubtedly *clinometric* mineral with such a peculiarly high angle between the optic axes, occurring in triangular plates and masses so much resembling the micas from Monroe, N. Y., whose biaxial character is so difficult of determination, and which by reason of this form have been referred by some eminent crystallographers to the rhombohedral system. The form in both cases may be considered as resulting from an acute oblique rhombic prism by the replacement of the acute solid angles.*

Examined with the blowpipe the mineral gives the following reactions.

B.B. in the forceps, contracts and becomes opaque and white, with traces of fusion on the edges. Alone, on charcoal, same as with forceps. In an open tube, gives off water, and a white ring is formed near the assay when strongly heated. With borax in the oxydating flame, dissolves readily with much ebullition; the glass while hot, red and brownish, but becomes

* Dana's Mineralogy, 1st edition, p. 264, and Am. Jour Sci., 2d Ser., xii, p. 8.

green when cold; in the reducing flame, while hot, color not so deep as in the oxydating flame, and passes through the shades of olive green while cooling, to beautiful emerald green when cold. With phosphate of soda and ammonia in the oxydating flame, dissolves slowly, leaving a skeleton of the fragments; glass red and yellowish while hot, fine green when cold. When much of the assay is added, the glass becomes opalescent to opaque when cooling; in the reducing flame, skeleton disappears, bead brown while hot, opalescent and green while cold. With carbonate of soda on platina foil, no reaction for manganese.

The constituents of the mineral so far as indicated by the above reactions are, Ḧ, S̈i, C̈r, F̈e. Analyses are now in progress at the Yale Analytical Laboratory.

In addition to the optical character, the mineral is shown to differ from chlorite in hardness and elasticity, and by the presence of chromium.

I propose for the species the name *Clinochlore*, in allusion to the great obliquity between the optic axes, and its green color resembling that of chlorite.

A similar mineral from Unionville occurring in triangular and hexagonal forms, I have found to be biaxial and probably like the above; but I have not yet succeeded in obtaining any measurements.

ART. XXXV.—*Notes of a Discussion of Tidal Observations made in Connection with the Coast Survey, at Cat Island, in the Gulf of Mexico;* by Prof. A. D. BACHE, Superintendent,* with five plates.

IN executing the hydrography of the entrance of Mobile Bay and of Mississippi Sound, connected tidal observations were made under the immediate direction of Lieut. Comd'g. C. P. Patterson, U. S. N., Assistant in the Coast Survey.

The observations at Cat Island, at the entrance to Lake Borgne, Louisiana, and at Fort Morgan, at the entrance to Mobile Bay, have undergone more than one discussion, the peculiarities of the tides giving great interest to the observations.

The results, as obtained from a year's hourly observations day and night at Cat Island, will be given as far as obtained, the steps taken for further progress stated, and the information which has been obtained from other sources bearing upon this most interesting problem of the tides in the Gulf of Mexico, will be briefly touched upon.

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* From the Proceedings of the American Association for the Advancement of Science, 4th meeting at New Haven, 1850, p. 281. Revised by the author for this Journal.

I hope, in the progress of the Survey along this part of our coast, to develop the subject of these tides, full of importance to the navigator, and of interest to the man of science. These tides, with special exceptions, ebb and flow but once in twenty-four hours.

The tide gauge was of the kind known as the box gauge, with a float and staff, graduated into feet and decimals of a foot. It was placed in the harbor of Cat Island, near the light-house, at the extremity of a temporary wharf.

The harbor, as the Coast Survey chart which I now present to the meeting shows, turns its widest and deepest opening to the East.

Apparent time was given by a mark, and the observations were made at mean solar time by applying the equation. The time was of less consequence than ordinary in these observations, from the small rise and fall of the tide, which prevented small differences of time from being noticeable by differences of rise and fall. Slight inequalities, caused chiefly by wind, were also found to affect the observations so materially that it was not deemed advisable to observe oftener than once the hour; and after attempting to determine the epoch of high and low water by more frequent observations, it was decided that errors would probably be introduced by aiming at a degree of precision which the phenomena themselves did not present.

The observations were made day and night, hourly, for a year, with exceedingly rare omissions, and, as the discussion has shown, with a degree of faithfulness which merits very great praise. The observers were Messrs. Gustavus Wurdeman and R. T. Bassett, attached to the Coast Survey.

The general opinion of nautical men on the subject of these tides is, that they mainly depend upon the action of the wind; and the very regular effect which may be shown to result from a discussion of the tides in reference to the local action by the wind, lends plausibility to this generalization, which nevertheless is unfounded.

The causes are of a much more general character, and such as usually influence the tides, so modified as to be difficult to bring out; phenomena which are only accessory in the ordinary discussions assuming here the chief and overruling part.

The regular tabulation of the observations was made by Lieutenant Comd'g. C. P. Patterson, who did not fail to perceive that the ordinary methods of discussion of the tides were inapplicable. His removal from the Survey on other professional service has devolved upon me the labor of discussing the results.

Their importance, interest, and novelty, so far as our coast and their striking peculiarities are concerned, have justified me in giving much time to the discussion, which has been carried on

under my immediate direction, by Mr. G. W. Dean, Sub-Assistant in the Coast Survey, and by Messrs. R. M. Bache, A. S. Wadsworth, Jr., and W. M. Johnson.

I am indebted for the diagrams necessary to illustrate the conclusions already arrived at, to Messrs. Bache, Johnson, and Keyser.

I present a part only of the labors of these gentlemen. The whole of the hourly observations for the year have been thrown in the form of curves, and numerous tables for examining and verifying the different hypotheses have been made by them. Though the subject was reached inductively, I do not propose to present it strictly in that form.

The work even now is far from being complete; indeed we have rather reached the true method of discussion, than have completed the discussion; and we may yet have to modify our hypothesis, though I think not materially. I present it to the Association as a work in *progress*. When the investigation for this station is made complete, the application of the methods to the other stations on the Gulf of Mexico will be in a degree mechanical.

It is curious that one among the earliest complete series of tidal observations on record, is of tides ebbing and flowing but once in twenty-four hours. The observations were made by Mr. Francis Davenport, at Batsha, of the tides on the bar of Tonquin, and communicated to Dr. Halley, who gave them, with a diagram connecting the phenomena with the moon's motion in the ecliptic, in the thirteenth volume of the Philosophical Transactions for the year 1683. Newton explained these tides by his lunar theory, but in a way, as appears to me, to leave it doubtful whether he supposed the interference of two ordinary or six hour tides to produce the phenomena. These tides have been referred to since by almost every writer of note, who has given a general theory of the tides.

The subject of the diurnal inequality of the tides has been so completely and ingeniously discussed by Mr. Whewell, Master of Trinity, that it may be said emphatically to be his own. He first pointed out the empirical law of variation of this inequality. The first distinct attempt to trace the cause of apparent ebb and flow once in twenty-four hours to the influence of the diurnal irregularity, is also, so far as I know, his. In discussing (Phil. Trans. for 1837, Part I,) the tides at Singapore, where the diurnal inequality is very large, he was led to the conclusion, if carried a little further, "at a certain stage of it the alternate tides would vanish." To this effect he attributed the "single day tides of King George's Sound, on the coast of New Holland, as observed by Captain Fitz Roy," and gives the curves for a week's observations on the diagram accompanying his papers. The progress of the diurnal inequality wave along the coast of Europe forms

an interesting part of Mr. Whewell's labors, the conclusions of which are given in the same volume of the Phil. Trans.

In all these cases, however, there are two tides in the course of the day, so as to bring out the diurnal inequality by the comparison of the consecutive high or low water. The subject is followed up in the eleventh series of tidal researches by Mr. Whewell, and in the appendix, in which the diagrams of the tides of Petropaulofsk, in the Bay of Avatcha, Kamtschatka, approaching very nearly, at certain parts of the lunar month, to the order of single day tides, is given, to prove that the diurnal inequality may be so large "as to lead to the appearance of only one tide in twenty-four (lunar) hours." The equations of the diurnal and semi-diurnal tide waves are given in this paper, and the wave produced by certain cases of their interference is discussed. (Phil. Trans. for 1840.)

I do not pretend to give such notice of these important papers as would be necessary in a formal communication. Unquestionably the observations now under examination would have furnished to Mr. Whewell only the means of trying ideas and consequences flowing from those which have been already discussed by him, yet the forms of discussion are original, and perhaps new, and the conclusions present so much of novelty that they remain to be fully put to the test by more elaborate discussion, and by bringing the results at other places to bear upon the same question. I am forced by the necessity for brevity to omit a reference to the learned, ingenious, and elaborate paper of Mr. Airy, in the Phil. Trans. for 1848.

The small rise and fall of the tides, amounting on the average to but one foot, would seem to make it difficult to obtain the law of the phenomena, even with the aid of the most careful and truthful observations, the class to which those under discussion have proved to belong. In regard both to time and height, we may expect to be baffled by small irregularities, requiring long continuance of observations and comparisons of means, to get rid of. Thus far, few cases have occurred which do not exhibit more striking coincidences than differences.

1. To show the time of high or low water in such a way that the discussion might be readily generalized, the diagrams, of which a specimen is before the Association, were made (Pl. 3, or No. 1); the hours of the day are the ordinates, and the days of the month the abscissa. The signs H and L show in their proper place the hour of occurrence of high and low water for each day. The time of the moon's superior transit is marked, and the periods of greatest declination, and of crossing the equator. The result is easily generalized, that there is ordinarily but one high and one low water at Cat Island in twenty-four (lunar) hours, and that when there are two tides they occur about the time of the moon's

crossing the equator, and are usually most regular and strongly marked when in syzigies, with declination nearly zero. Following one set of high and low waters, it will be found that they occur later and later as the lunar day gains on the solar, with very remarkable differences, of which the explanation will be given, towards the period of small declinations. The interval from high to low water is generally less by some hours than that from low to high. That as the moon approaches the equator, there are a few days of singular double tides, or of single tides, in which the times from low to high water are very much increased. That when the declination changes its name, a high tide takes nearly the place of a low in time, and *vice versa*, with an interval of irregularity, or, in other words, the tides are displaced by nearly twelve hours.

2. There is, as Mr. Whewell has remarked, no proper establishment to be derived from such tides; yet we may obtain a desirable datum by throwing the results into the form of tables, in which the luni-tidal intervals are arranged according to the days from the zero of declination and the corresponding superior and inferior transits, and for north and south declinations. This will be made more clear by subsequent explanation. These afford a test of the theory of these tides, by showing the displacement of the ordinate of high and low water, and might be used for the inverse purpose of forming prediction tables. Such tables of luni-tidal intervals for three months I now submit. They show considerable steadiness and similarity of intervals towards the maximum of declinations, and great variations near the zero, and greater discrepancies than is usual in ordinary tides. These are from a series of tables computed by Mr. R. M. Bache for the year, and containing the times of high and low water, deduced from the daily curves, the readings of the gauge, the rise and fall of the tides, the times of the moon's superior and inferior transit, and the moon's declination.

The intervals serve to show that the high water belongs alternately to the superior and inferior transits of the moon, according as the moon's declination is north or south, with a few cases only which admit of doubt. Two sets of luni-tidal intervals were computed (see tables) for three months, to ascertain the proper epoch of reduction (or age of the tide). In one case the intervals were referred to the superior transit of one day before, and in the other to the superior transit of two days before. The square of the discrepancy of the mean in the latter case was greater than in the former. An establishment deduced from these numbers for high water without correction would have a probable error, as tried by discrepancy from the mean, of nearly eighty-four minutes. I have little doubt of being able to reduce this error, by computation, much within the limits of observa-

tion, so as to give useful prediction tables. The foregoing results point distinctly to a ruling cause depending upon the moon's declination.

3. The hourly observations for the year were thrown into the form of curves, the abscissas representing the hours and the ordinates the heights. Of these I present, as characteristic, the months of January and March (Pl. 4, 5, or Nos. 2, 3). In January the tides are single throughout the month, the rise and fall diminishing towards the zero of declination; and in March two periods of marked double tides occur. The times of new and full moon coincide nearly with the zero of declination of March; in January the syzigies occur at times of greatest declination. A series of diagrams, prepared for periods of declination zero, shows irregularities or double tides near these times. Before disappearing, the tide which is lost appears rather as an irregularity than as a real tide, puzzling to the observer and a severe test of his faithfulness. A similar set of diagrams for the periods of greatest declination show uniformly single tides and the greatest comparative rise and fall at the same periods, whether coinciding with syzigies or with first and last quarters. In computing the heights of spring and neap tides by the common methods, four months gave zero or negative differences.

To discuss the epochs of the phenomenon, as compared with greatest and least declinations, I prepared two sets of tables, which require revision.

They show sometimes an actual coincidence in the epoch of least tides and zero of declination, sometimes a precedence and sometimes a subsequence, which, when not caused by irregularity of winds, I believe will find a satisfactory explanation; at a mean, there was little advantage in the discussion found from displacing the epoch. The average rise and fall for the second day before the greatest declination was 1·68 feet, for the day next preceding the greatest declination 1·78, for the day of greatest declination 1·81, for the next day 1·86, and for the next 1·77. Tracing a curve from these would give the epoch of greatest rise and fall about 0·75 days after the greatest declination. The average rise and fall on the corresponding days, in reference to declination zero, were 0·96 feet, 0·75, 0·60, (dec. zero,) 0·63, 0·73, the curve giving the epoch about one-sixth of a day after the zero of declination. The numbers, as stated, require revision; and there are causes for an apparent displacement, which require further examination.

4. This general examination tends to point to the diurnal irregularity, as Mr. Whewell has stated, as the cause of the occurrence of these single day-tides; a view which is confirmed by such examinations as I have been able to make of the hourly tidal observations at Fort Morgan, at the entrance of Mobile Bay.

The interference in this case would be between the diurnal tide-wave, which represents the diurnal inequality and the ordinary semi-diurnal wave, whether this wave has a regular progress along the coast independently of the semi-diurnal wave, as was at first supposed by Mr. Whewell, or whether its phenomena are local, as he has since been led from his investigations to believe. If the observed wave is produced by its interference with a semi-diurnal wave, we can only study the phenomena to advantage after the observed wave has been separated into its components.

5. As a first approximation, I assumed the two waves to be governed by the law of sines, and then determined the curve which would result from the superposition of two such waves, having the same or different origins. The mean of the regular double tides about the zero of declination would present a first approximate value of the rise and fall of the semi-diurnal tides, and the mean of double and single tides at the maximum of declination would, especially when near the quadratures, give a first approximation to the height of the diurnal tide. The comparisons with the forms of curves already traced, addressing the eye, are easily made.

I present herewith diagrams (Pl. 6, or No. 4) for the case, in which the maximum of the diurnal tide coincides with that of the semi-diurnal, is three hours in advance, (or coincides with mean water falling,) six hours, (or coincides with low water,) and nine hours, (or coincides with the second mean, or mean water rising,) using the approximate quantities referred to above for the greatest height of two component curves. It requires little examination to see that neither of the first three forms represents the case, and that the fourth does so remarkably, even in what appear to be small irregularities in the daily curves. This will be seen in the results for October, of which a diagram on a large scale is presented, giving the tidal curves near the zero, and thence up to the maximum of declination for the first half of the month. In the single day tides there was the same slow rise compared with fall, sharp rise and fall near high and low water, with the tendency to a stand during the rise; the same excess in the interval of time from low to high water, over that from high to low water. This hypothesis as to the position of the two waves may perhaps be slightly improved by further discussion. It is obvious from the equation of the curve (which I have already referred to as given by Mr. Whewell), that the form and position of remarkable points will vary with the constants in the component curves, as well as with the position of the origin of each in reference to that of the other.

To carry out the representation graphically, I have drawn the curves for four values of the constants of the diurnal and semi-

diurnal, formed from the observations with the same displacement of nine hours in the time of high water of the diurnal curve, and corresponding to the epochs of the maximum declination, two, four, and six days before or after the maximum. These show the general features of the curve sufficiently, and the variations in the times and heights, the passage from single to double tides, and the reverse; and the coincidence with observations is such as to warrant a close numerical discussion.

6. The equation of the curve shows how the time of high and low water depends on the constants in the diurnal and semi-diurnal curve.

The equivalent of the equation given by Mr. Whewell is—

$$C \cdot \cos 2t + D \cos (t - E) - y = 0,$$

in which t is the time in hours from the place of the maximum ordinate of the semi-diurnal curve as an origin; C is the constant of that curve of sines; E is the distance of the maximum ordinate of the diurnal curve for the former, and D the constant for the curve of sines; y is the ordinate of the complex curve.

By an easy transformation, this takes the form,

$$2C \cdot \cos^2 t + D \cos t \cdot \cos E + D \cdot \sin t \cdot \sin E - C = y.$$

$$\text{For } E = 9 \text{ hrs.} \quad \text{Cos } E = -\sin E = -\sqrt{\tfrac{1}{2}},$$

$$\text{and } y = 2C \cos^2 t + D \sin E (\sin t - \cos t) - C.$$

The differential co-efficient of which for the case of the maximum or minimum is

$$\frac{dy}{dt} = -4C \cos t \cdot \sin t + D \sin E (\sin t + \cos . t) = 0$$

$$\frac{1}{\sin t} + \frac{1}{\cos t} = \frac{4C}{D \sin E} = \frac{4C}{D\sqrt{\tfrac{1}{2}}},$$

or, since the second term is negative when $t > 6$ hours,

$$\text{cosec} \cdot t - \sec t = \frac{4C}{D\sqrt{\tfrac{1}{2}}}.$$

Applying this to the four cases shown in the diagrams

		hrs.	min.
E = 9 hours, C = 0·175, D = 0·700	we find maximum at	10	25·4
= 0·615		10	33·3
= 0·400		10	51·1
= 0·157		11	56·8

and for the intervals between high and low water in lunar hours,

h.	m.	h.	m.	h.	m.		h.	m.
9	09·2,	8	53·4,	8	17·8,	and	6	06·4.

We might apply this mode to test the hypothesis, using for the values of C, the half difference of the ordinates of six and twelve hours from the mean, and of eighteen and twenty-four hours with the signs changed, and for D, the average of the or-

dinates of six and eighteen hours from the first mean. The means present the best criterion because not displaced in this combination as the equation shows. This mode of proceeding, however, throws the test too much on the weak part of the results, the times of occurrence of high and low water, or of mean water, and does not take in all the points of the curve, and I have therefore preferred a different form of discussion.

7. Placing the maximum of the semi-diurnal curve at 0 hours, in the hypothesis that the high water of the diurnal curve is nine hours in advance of that of the semi-diurnal curve, the two curves cross the line of mean water at three hours, the diurnal curve rising and the semi-diurnal falling; at six hours, the semi-diurnal curve has reached its maximum, and rises again at nine hours to its intersection with the mean water line, at which time the diurnal curve has reached its maximum; the semi-diurnal curve attains its greatest rise at twelve hours, and the mean level at fifteen; the diurnal curve also descending to the same point at that time.

Within these two intervals from mean level to mean level, the combinations of the ordinates forming the actual tidal curve are exhausted; the part of the curve below the mean level being symmetrical with that above. From three to nine hours, the ordinates of the semi-diurnal curve are subtractive; from nine to fifteen hours, additive. The mean is the average between high and low water. The tides of each day will give the forms of the component curves, beginning with the mean, and ending with it, considering as symmetrical the parts above and below the axis of X.

In tabulating, the branch above the axis should be referred to the mean of the preceding and succeeding low water $\left\{\frac{1+1'}{4}+\frac{h}{2}\right\}$ and of the high water which it includes, and that below to the mean of the two high, and of one low water. From three to nine hours, the difference of the ordinates giving the actual curve, and from fifteen to nine in the reverse order the sum of the same ordinates, half the sum of the two series of ordinates gives the value of the ordinates of the diurnal curve, and half the difference, the ordinates of the semi-diurnal curve. The same being repeated with the second branch of the curve, the average will give two results for each day's observation.

The case given in the table on the board, for March 5, will serve to illustrate the simple nature of this method of proceeding.

The mean ordinate for the first and second branches of the curve having been obtained, and the hourly observation which coincides most nearly with it having been found before and after high water, the hourly observations are arranged from it forwards

for seven hours (m) and backwards for seven (n). The same is done for low water, (m′ and n′.) The half sums and half differences are taken in each case, and then the means. The computation of the diurnal curve is made in the upper part of the table, and that of the semi-diurnal curve in the lower part. The number representing the mean level is eliminated by the mode of taking the means in each table, and the ordinates below the axis are treated as if having the same sign as those above. The semi-diurnal curve is turned over on its maximum ordinate, and the mean value of a single branch of it found. Then each curve is reduced to zero, in the mean level of the period. The last two columns of the upper and lower part of the table contain respectively the curves of sines corresponding to the diurnal and semi-diurnal curves.

In the case shown in the first diagram, the ordinates of the semi-diurnal curve from mean water to high water, and corresponding nearly to a minimum of declination, and new moon, are 0·00 feet, + 0·02, + 0·03, + 0·05, + 0·04, − 0·02, + 0·02. The moon's declination during the period being about from 2° 54′ S., to 1° 45′ S.; this curve obviously contains a residual of the semi-diurnal curve, not taken out, but supposing it to be deduced from a just mean, the corresponding ordinates of a semi-diurnal curve, calculated with 0·04 feet as the maximum would be 0·00 feet, 0·01, 0·02, 0·03, 0·03, 0·04, 0·04, differing at the most, 0·06 of a foot, or about three-quarters of an inch, and in a single instance, the sum of all the six differences being 03 feet, and the average ·004.

The ordinates of the semi-diurnal curve are 0·00 feet, 0·14, 0·28, 0·32. The curve of sines computed with the greatest ordinate has in this case for its corresponding ordinates 0·00 feet, 0·16, 0·28, 0·32, differing but ·02 feet at the greatest.

At the next period of declination nearly zero, and full moon in the month of March, the ordinates of the diurnal curve deduced are 0·00 feet, 0·05, 0·06, 0·06, 0·08, 0·06, 0·09, and the corresponding computed ordinates 0·00 feet, 0·02, 0·04, 0·06, 0·07, 0·09, 0·09, differing at the greatest 0·03 feet, and on the average, 0·004 feet, the observed ordinate being this time in excess as it was before in defect. The ordinates of the semi-diurnal curve are 0·00 feet, 0·12, 0·22, 0·26, and the computed ones, 0·00 feet, 0·13, 0·24, 0·26, the greatest difference being 0·02 feet, and the average 0·007 feet in excess, as was the former.

For March 12, corresponding to the maximum of the diurnal curves, and to neap tides (one day after last quarter), the ordinates of the hourly diurnal curve from mean to high water are 0·00 feet, 0·21, 0·36, 0·51, 0·63, 0·69, 0·71, the corresponding ordinates of the curve of sines being 0·00 feet, 0·18, 0·35, 0·63, 0·69, 0·71, in which the greatest difference is 0·03 feet, and the

mean +0·007 in the curve computed from observation. The ordinates of the semi-diurnal curve are each zero. Two days afterwards, viz. March 13, gives for the diurnal curve, 0·00 feet, 0·18, 0·34, 0·47, 0·61, 0·68, 0·74, corresponding to which is the curve of sines 0·00 feet, 0·18, 0·37, 0·51, 0·63, 0·72, 0·74, in which the greatest difference is 0·04 feet, and the mean −0·02 feet, the curve of observation having the least ordinates. The semi-diurnal curve is 0·00 feet, 0·00, 0·03, 0·02.

The average of three months, taken by weeks, gives for the mean curve and curve of sines the following table:—

Hours.	Diurnal Curve.			Semi-Diurnal Curve.	
	From Observat'n. Feet.	Of Sines. Feet.	Diff.	From Observation. Feet.	Of Sines.
0	0·00	0·00		0·00	0·00
1	0·17	0·15	0·02	0·04	0·04
2	0·32	0·30	0·02	0·07	0·07
3	0·43	0·42	0·01	0·08	0·08
4	0·52	0·52	0·00		
5	0·56	0·58	−0·02		
6	0·58	0·60	−0·02		
		Sum	0·01		

These results are shown by a curve in the diagram herewith presented (Pl. 7, or No. 5,) on the full scale,* the greatest difference between the curve from the observation and the curve of sines being less than a quarter of an inch in the mean deduced from three months observations. Whether this will disappear in the mean of more observations or whether a modification of the hypothesis of displacement of nine hours must be made to meet it, further computations now in progress will show.

8. When this analysis has been made as complete as possible, and applied to the year's observations, it will remain to take up the two series into which we have divided the observations, and to discuss them numerically in detail, as we have heretofore done, generally, in regard to the known laws of the diurnal irregularity, and of the ordinary tides.

Each determination gives a corresponding value of the maximum, or of the ordinate of high water, and in the case of the mean of the curves for January, February, and March, these maxima are 0·66 feet, 0·65, 0·60, 0·60, 0·58, 0·58. Mean 0·61 feet, differing ·03 of a foot, from the maximum found directly from the observations, and if the discrepancies are accidental, giving a mean probable error by the variations from the average of 0·02 feet (one-quarter of an inch) of any one of the determinations, and for the mean, 0·01 feet nearly.

9. By the kindness of Col. Abert, of the Topographical Engineers, of Major Bache, of the same corps, and of Lieut. Maury, Superintendent of the National Observatory, I have been put in

* Reduced in the plate.

possession of tidal registers which have been kept during the progress of the local surveys made of harbors on the coast of the Gulf of Mexico. The tidal observations of Major Bache, U. S. Topographical Engineers, at Key West and the Tortugas, are the most complete of this series, and show, as a general phenomenon, the prevalence of the semi-diurnal wave at that point. I have not yet had the opportunity to examine fully these results, which are however under discussion.

ART. XXXVI.—*The Silurian Basin of Middle Tennessee, with notices of the Strata surrounding it;* by JAMES M. SAFFORD, A.M., Prof. of Chemistry and Geology, Cumberland Univ., Lebanon, Tenn., with a plate.

1. THE rocks of Middle Tennessee, west of the Cumberland Mountains, belong, for the most part, to strata below the Pentremital carboniferous limestones.

2. They may be divided into *five* natural but unequal groups, (see table, § 7.)

The *First* and *Second*, commencing with the lowest, comprise the "Blue limestones" of western geologists.

The *Third* includes the gray limestone of the Harpeth and Tennessee rivers.

The *Fourth*, the well known "Black slate."

The *Fifth* and uppermost, the "siliceous stratum" of Dr. Troost—a heavy group, often including limestone, but well marked everywhere by its siliceous character.

3. The strata of these groups, originally, formed a slightly elevated dome, the denuded summit of which is in Rutherford county. Here the lowest of the rocks under review are visible. From this point the dip eastward is very slight; towards the Illinois coal-field, however, it is considerable, being from four to five hundred feet in sixty miles, and sufficient to bring the uppermost group down to the level of the Cumberland river, in Montgomery county. Towards the south and west, the dip of the "blue limestones" is greater than that of the "black slate" and the siliceous group above, thus making room for the Harpeth and Tennessee river group.

4. The groups enumerated above have been denuded in such a way as to form a *basin*, its outlines more or less obscured by "spurs," hills, &c., though, upon the whole, well defined; it is of an oval figure, about one hundred miles long and fifty or sixty broad, and runs somewhat obliquely across the state. (See map, Plate 7.) I have denominated it the *Silurian* basin, since the rocks of the entire area are of Silurian age, the "blue limestones," or groups first and second, being the surface-rock of the level and rolling lands constituting the *bottom* of the basin.

5. Along the western side, the upper part of the second, the whole of the third, fourth, and fifth groups crop out on the hill-sides or bluffs forming the walls of the basin. Group *third*, which is seen only along the western side, in sections, thickens as we proceed south-westward, and emerging in the counties of Perry, Wayne, Hardin, &c., from beneath the superior groups, which separate our basin from the bottom-lands of the Tennessee, becomes the surface-rock of these lands and the knobs along the river. On the south-eastern side of the basin, the slopes, bluffs, &c., present sections corresponding to those of the opposite side, with the exception of the *entire absence* of group *third*, or the gray limestones of the Harpeth and Tennessee rivers. (See section, on the map.)

6. The uppermost group, including all above the black slate, spreads out into a broad zone encircling the basin on all sides. It thus forms the "Barrens" and flat lands lying along and in front of the western slope of the Cumberland Mountains; running eastward it disappears beneath the *Pentremital* strata forming their base. (See map.) From the mountains, the zone sweeps off in a north-westerly, and then westerly course, through North-Tennessee and Southern Kentucky, presenting us again with barrens and flat lands. In this region, the Cany fork and Cumberland river, intersecting the strata deeply, have cut out for themselves narrow valleys, remarkable for their depth, their precipitous bluffs, and the beautiful waterfalls of their tributaries. Bluffs five and six hundred feet high have been reported.

The zone disappears in Kentucky, under the limestone slopes of the Illinois coal-field. From this region, it extends, rich in oxyd of iron, south through Tennessee, running under the cretaceous rocks west of the Tennessee river. The latter river and its tributary, the Duck, have here intersected the two topmost groups and exposed (§ 5,) the limestones below. The zone completes the circle, by sweeping off to the east in North Alabama, until it again reaches the mountains.

7. The groups and their members will be noticed in the ascending order, commencing with the lowest, as follows:

V. Siliceous Group, { *b*—Cherty limestone. / *a*—Siliceous beds.

IV. Black or bituminous slate.

III. Harpeth and Tennessee River or gray limestone.

II. Nashville Group, { *c*—Upper Nashville beds. / *b*—Lower Nashville beds. / *a*—Siliceous, or sandy limestone.

I. Stones River Group, { *c*—Upper Lebanon limestone. / *b*—Lower Lebanon limestone. / *a*—Stones River beds.

8. The rocks of Middle Tennessee, equivalent to the "Blue limestone" around Cincinnati, and to the Hudson River, Trenton and Black River Groups of New York, are about five hundred feet thick. They comprise the first two groups, which, though having characters in common, are upon the whole natural, and separated by a well defined horizon. The lower of these and the first of our series is the

I. *Stones River Group.*

9. This group is so named from the name of the stream along which it is finely developed. It is limestone throughout, and from 240 to 260 feet in thickness. We have divided it, for convenience, into three members, though a more natural arrangement would unite the first two.

10. (*a.*) *Stones River beds.*—This includes a series of blue and brownish-blue limestones, mostly fine-grained and thick-bedded, some strata of which abound in dark flinty layers. These rocks —the oldest of Middle Tennessee—are about seventy-five feet thick, and form an irregular circle, with a diameter of ten or twelve miles, constituting the summit of the denuded dome in Rutherford, (§ 3.) The member differs from the one next above in its thick-bedded strata, and in not affording as many fossils, which, (together with the comparatively less study bestowed upon it,) will account for the paucity of species. The following is a list of those observed and collected; it will be seen that nearly all are common to the member succeeding.*

1. Stromatocerium rugosum, Hall.
2. Orthis bellarugosa, Conrad.
3. Atrypa hemiplicata, Hall
4. " recurvirostra? Hall.
5. Leptæna, allied to L. incrassata.
6. Pleurotomaria umbilicata, Hall.
7. Gonioceras anceps, Hall!†
8. Actinoceras tenuifilum, Hall.

11. (*b.*) *Lower Lebanon limestone.*—The irregular circle just mentioned is surrounded by a broad *zone* of thin-bedded layers, which—everywhere attended by "cedar glades"—sweeps off in opposite directions, reaching the Cumberland on the north, and Duck River, along which it spreads, on the south. This thin-bedded sub-group is from fifty to sixty feet thick and is well developed in and about Lebanon, which locality has afforded most of the species enumerated. The sky-blue layers—sometimes separated by seams of argillaceous matter—are coarsely crystalline and abound in calcareous remains.

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* All of the species given in this paper, with very few exceptions, have either been collected, or seen by myself, in situ, and it affords me pleasure to state, that, in comparing and making them out, I am greatly indebted to the valuable assistance of so able a Palæontologist as Prof. James Hall.

† The relative abundance of species when considerable is expressed as follows:—very abundant !!!—abundant !!—common !

List of Species.

1. Chætetes, n. sp. !! allied to lycoperdon.
2. " ? n. sp.
3. *Trematopora*, two new species.
4. Stictopora !! four or five n. sp's.
5. *Retepora fenestrata*, Hall.
6. Escharopora, n. sp.
7. *Graptolithus amplexicaulis*, Hall.
8. Schizocrinus, n. sp.
9. Fragment of a Cystidian, new genus.
10. " of a Sphæronites, n. sp.
11. Stems of Cystidiæ.
12. Leptæna incrassata, Hall !!
13. " sericea, Sowerby.
14. " filitexta, Hall.
15. " three sps. new and undeter.
16. *Orthis deflecta*, Conrad !!*
17. " *subæquata*, " !!
18. " *perveta*, "
19. " *tricenaria*, " !
20. " bellarugosa.
21. " sp.? allied to disparalis.
22. Atrypa increbescens?
23. " sp.? allied to recurvirostra.
24. *Ambonychia amygdalina*, Hall.
25. " *obtusa*, Hall.
26. *Edmondia ventricosa*, Hall.
27. *Maclurea magna*, Lesueur.
28. Pleurotomaria umbilicata, Hall!
29. Pleurotomaria subconica, Hall!
30. " *lenticularis*, Sowerby.
31. *Subulites elongata*, Conrad!
32. Holopea, n. sp.
33. " allied to obliqua.
34. Murchisonia bicincta, Hall!
35. *Cyrtolites compressus*, Conrad.
36. *Bucania bidorsata*, Hall.
37. " *expansa*, "
38. Carinaropsis, n. sp.
39. Endoceras proteiforme, Hall!
40. " n. sp.
41. Orthoceras fusiforme, Hall!
42. " multicameratum? Hall.
43. " undulostriatum? "
44. Actinoceras tenuifilum, Hall!
45. Gonioceras anceps, Hall.
46. Oncoceras constrictum, Hall!
47. Lituites, 2 n. sps.
48. Cyrtoceras, allied to arcuatum, Hall.
49. *Cytherina fabulites*, Conrad !!!†
50. Ceraurus pleurexanthemus, Green.
51. Calymene Blumenbachii, "
52. Illænus ovatus, Conrad.
53. " sp.?
54. Phacops callicephalus, Hall.
55. Isotelus megistos.
56. Tail of Lichas.

12. (*c.*) *Upper Lebanon limestone.*—The limestone last mentioned passes gradually into a heavy member of grayish, sometimes brownish, blue thick-bedded layers. Such is their character for the most part; within fifteen or twenty feet of the top, however, the layers become thin-bedded, interstratified occasionally with seams—rarely beds—of clay. The entire thickness is from one hundred and ten to one hundred and thirty feet.

This member runs in an irregular belt around the last, enclosing the inferior rocks and disappearing without, beneath the succeeding group. It forms, in addition, within the *belt*, the bases of two broken lines of ridges and hills—respectively the water-sheds of Stones River and the Cumberland, and of Stones and Harpeth on the north and Duck River on the south—thus cutting off the minor basin of Lebanon, and, east of Columbia, that of the Duck River.

The middle portion of the member is every where characterized by groups of *silicified Columnaria alveolata*, *Streptelasma profunda*, Hall, and the rough spherical masses *Stromatocerium rugosum*, to which we may add *Actinoceras tenuifilum;* fossils,

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* O. deflecta has been described by Mr. Conrad, from an imperfect Wisconsin specimen, as Strophomena deflecta, and the same individual is figured in New York Pal., vol. i, under Leptæna; it is however a true Orthis.

† Cytherina fabulites, so far as I know, has never been figured; having seen Mr. Conrad's original specimen I can have no doubt as to its identity with mine.

however, are not very abundant, and hence our list is by no means as long as the last.

List of Species.

1. Stromatocerium rugosum, Hall !!
2. *Columnaria alveolata*, Hall !!
3. *Astrocerium*, n. sp.
4. Chætetes lycoperdon? Hall.
5. " columnaris, "
6. *Streptelasma profunda*, " !
7. Clathropora, sp. undescribed.
8. Stictopora, two new species.
9. Atrypa recurvirostra, Hall.
10. Leptæna filitexta, "
11. *Pleurotomaria rotuloides*, Hall.
12. " subconica, "
13. Murchisonia bicincta, "
14. Actinoceras tenuifilum, " !!
15. Orthoceras anellum ?
16. " multicameratum ?

II. *Nashville Group.*

13. This group is not as easily subdivided as the last; the lowest portion, however, including from sixty to eighty feet, is a well characterized member; the remainder, which is about two hundred and sixty feet thick, not affording grounds for a positive division, has simply been divided equally into Upper and Lower Nashville beds.

14. (*a.*) *Siliceous or Sandy limestone.*—The aspect of this, the first subdivision of the group, is quite different from the purer limestone below; it is mostly a thick-bedded, coarse-grained, gritty, and, when freshly quarried, dark-blue, limestone. By weathering it loses its calcareous matter and becomes often a soft yellowish sandstone or shale.

This member abounds in individuals of *Orthis testudinaria*, which is highly characteristic, not having been noticed in any other position within the basin. This sub-group, forms a zone enclosing, and concentric with, those described.

List of Species.

1. Chætetes lycoperdon !
2. Leptæna, sp. !
3. *Orthis testudinaria* !!!
4. Atrypa increbescens.
5. Spirifer lynx.
6. *Small Acephal*, new !!
7. *Modiolopsis anodontoides.*
8. Holopea ? !

15. (*b* and *c.*) *Nashville beds, Lower and Upper.*—Succeeding the last, we have thick-bedded strata of blue and blackish-blue limestone running up into thinner layers, separated by seams, and rarely beds of shale. These rocks are generally granular, often gritty and impure, and prone to disintegrate.

About Nashville, there are two minor beds, which, though of limited extent, are of sufficient interest to be noticed. The first is a bed, at the base of the series, of light clouded blue limestone, from twenty to thirty feet thick, and extensively used for building. It is peculiar in being made up, as is shown on weathered surfaces, of finely comminuted fragments of shells, which, together with the oblique lamination observable, proves it to have been deposited from a strong current. This is followed by a few

strata of whiter, more compact limestone, in some places eight feet thick and not granular as the last. Above these, again, and separated by several feet of the ordinary limestone, follows the second interesting bed. It is peculiar in being of a yellowish gray color, in being almost entirely an aggregation of individuals of a *Bucania*, *Murchisonia bicincta*, and of fine specimens of an undescribed *Acephal*, and also in its porous character due to cavities formed by the grouping of the shells. The bed is from eight to ten feet thick and has been noticed by Dr. Troost in his reports.

In the following list of species, those which are confined either to the upper or lower part are distributed accordingly.

1. Streptelasma, sp. und. Upper.
2. Chætetes lycoperdon, Say. !!!
3. " *constellata*, Vancleve. Upper !!
4. " columnaris, Hall.
5. *Favistella stellata*, "
6. Receptaculites? n. sp.
7. Astrocerium? n. sp.
8. Stictopora, n. sp.
9. Stromatocerium, n. sp.
10. Schizocrinus (stems.)
11. *Cyathocrinites conglobatus*, Troost. Up.
12. *Asterias antiqua*, Troost. Upper.
13. Leptæna alternata, Conrad !!!
14. " sericea, Sow.
15. " planoconvexa, Hall. Upper.
16. *Orthis sinuata*, Hall. Upper !!
17. " *subjugata*, " " !!
18. " *pectinella*, Conrad.
19. " undescribed.
20. Spirifer lynx, Eich. !!
21. Atrypa increbescens, Hall. !!!
22. Atrypa modesta, Say !!!
23. *Ambonychia radiata*, Hall.
24. *Avicula demissa*, Conrad.
25. Two new gen. of Acephals.
26. *Pleurotomaria bilix*, Conrad.
27. " n. sp.
28. *Murchisonia bellacincta*, Hall.
29. " *subfusiformis*, Hall.
30. " bicincta, Hall.!
31. " sp.?
32. *Bucania punctifrons?* Conrad.
33. " n. sp.
34. *Cyrtolites ornatus*, Conrad.
35. Oncoceras constrictum, Hall.
36. " n. sp.
37. Orthoceras multicameratum?
38. " lamellosum.
39. Gonioceras, n. sp. Lower.
40. Cyrtoceras macrostomum? Conrad.
41. Actinoceras tenuifilum, Hall. Lower.
42. Cytherina, n. sp.

III. *Gray limestone, or Harpeth and Tennessee River Group.*

16. Here we reach a horizon wholly distinct in every respect from the last.

Along the southeastern escarpments of the basin, the *black slate* rests directly upon the layers of "*blue limestone*" containing Spirifer lynx and its associates, (§ 5.) Passing westward, however, the group under consideration intervenes, and thickens, as is shown by the bluffs of the Harpeth and Duck rivers, as we proceed. Thus, like a great wedge, it separates two groups, which are adjacent on one side of the basin, making them in fact unconformable. Along the Tennessee river the group is well developed. The "Cedar Glades" of Perry, Decatur and Hardin counties have become already, by the researches of Dr. Troost, classic ground to the Palæontologist. The group, no doubt, includes rocks both of Upper Silurian and Devonian age. In Sumner county, but a few feet below, the slate *Pentamerus oblongus* may be gathered in abundance, affording evidence that along the northern slopes the strata are mostly Upper Silurian.

If so, the Devonian division thickens towards the southwest. The thinning out of the strata and the commingling of the fossils render it difficult to make the separation.

The following is an approximate section of the rocks, along the Tennessee, commencing with the lowest.

First, a stratum of impure blue limestone, thin-bedded and fine-grained, of unknown thickness, forty or fifty feet of which are exposed in the bluffs and beds of several creeks in Hardin county. It is a good hydraulic limestone and is beautifully laminated in smooth layers, which are from one to five inches thick. It has afforded me, as yet, no fossils, and hence its age is uncertain.

Then follow from 100 to 130 feet of limestone, mostly light-gray and thick-bedded, containing crinoidal beds; some of the lower strata with bright green points; middle strata banded by *reddish* layers which are, generally, fine-grained, impure, cherty limestone, common on the Glades; upper portion sometimes affording bluish layers of siliceous limestone; all often of a marly nature, easily disintegrating, forming the angular gravel of the Glades and liberating their siliceous and calcareous fossils.

List of Species.

1. Astrocerium constrictum, Hall.
2. " venustum? "
3. " ? n. sp.
4. Lichenalia, n. sp.
5. Stromatopora, n. sp.
6. Ceramopora, n. sp.
7. Stictopora crassa, Hall.
8. Fenestella elegans, "
9. " tenuiceps? Hall.
10. " n. sp.
11. Favosites gothlandica, Lam.
12. " niagarensis, Hall.
13. Syringopora, n. sp.
14. Catenipora escharoides, Lam.
15. Streptelasma calicula, Hall.
16. " n. sp.
17. Cyathophyllum? three n. sp.
18. Cystophyllum?
19. Caryocrinus, Troost's sp's.
20. Pentremites Reinwardtii, Troost.
21. Balanocrinus sculptus, Troost.
22. Eucalyptocrinus, Troost's sp's.
23. Gilbertocrinus Americanus, Troost.
24. Platycrinus Ann Dixoni, Troost.
25. Cupellæcrinus, sp's. of Troost.
26. Haplocrinus, " "
27. Leptæna depressa, Sowerby.
28. " subplana, Conrad.
29. Spirifer crispus, Dalman.
30. " undescribed.
31. " undulatus?
32. Calceola sandalina, Lam.
33. Atrypa obtuso-plicata, Hall.
34. " rugosa, Hall.
35. " lævis?
36. " three sp's. undes.
37. " aspera, Dalman.
38. " reticulatus, "
39. " Wilsoni, Sow.
40. Orthis elegantula, Dalman.
41. " hybrida, Sow.
42. " punctostriata? Hall.
43. Pentamerus oblongus.
44. " galeatus, Dalman.
45. Platyostoma niagarensis, Hall.
46. Phacops Hausmanni.

IV. *The Black Slate.*

17. This group, or stratum, cropping out around the escarpments of the basin, forms a well defined horizon. (See map.) It is already known, through the notices of Troost and others, as a brownish black slate, often bituminous, and containing iron pyrites, which is especially abundant near the base of the stratum. When exposed to damp air and at the same time protected from

rain, it is frequently encrusted with alum salts and copperas, due to the decomposition of pyrites.

In the northern part of the state, it is from forty to sixty feet thick, but thins out almost entirely towards the southwest; in many places often, as along Buffalo river, and in Hardin county, but a few inches of it are to be seen, sometimes scarcely a trace —a fact expressed upon the map by the broken part of the heavy line.

I have not been able to discover more than three small shells, of which but one has been well made out. In addition to the shells it occasionally affords fragments of leaves and wood. A *Lingula*, the shell referred to above, has been figured by Owen and Norwood in a pamphlet, entitled, "Researches among the Protozoic and Carboniferous rocks of central Kentucky." They consider it allied to L. spatula of the Genesee slate, though it is rather broader in proportion to its length. One of my specimens is a new species of *Chonetes;* it was obtained, together with the others in Maury county.

V. *Siliceous Group.**

18. This series—the "siliceous stratum" of Dr. Troost—included between the black slate and the pentremital limestone, is well marked throughout by its siliceous characters.

There appears to be doubt as to the age of the lowest beds, some regarding them as Devonian, others as carboniferous; we are inclined to adopt the latter view, and have upon the map regarded the entire group as carboniferous. The species are certainly closely related to carboniferous types.†

19. This series has been divided into two members.

(*a.*) *Siliceous beds.*—This member, including in the northern part of the state about 200 feet, appears to have had partly a chemical, and partly a mechanical origin. It consists mostly of a fine-grained, siliceous rock—sometimes approaching a fine sandstone; when freshly quarried, it is of a light blue color, and compact; it contains but little calcareous matter, and is often interstratified with layers of hornstone or flint;—occasionally beds of bluish siliceous shale are met with. Upon exposure, the rock, especially when more than usually calcareous, decomposes, losing its blue color and becoming a soft, mostly yellow, sometimes grayish, sandstone or shale. The Lebanon and Sparta turnpike exposes an entire section at Snow's hill, which

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* This interesting series requires far more study than has been bestowed upon it; the fossils especially, excepting the Crinoids which Dr. Troost has described, are new and need to be worked out. I trust, however, that the following notice made out mostly from personal observations may add something to what was before known of these rocks. See, in addition, Troost's reports.

† See Researches of Owen and Norwood before referred to.

is, from top to bottom, soft, yellow, siliceous or sandy shale, with heavy interstratified layers of hornstone.

The rock is generally thinly *dotted* with siliceous—sometimes calcareous—concretions; the larger occurring in the upper, more calcareous portion, are often fine geodes of quartz lined with crystals; one locality, at least, affords rhombohedral forms.

An interesting feature of these rocks—in fact of the group—is the presence of *Crinoidal limestone.* It occurs at various elevations in intercalated beds, ranging from one to ten feet in thickness; some of these are pure grayish-white limestone made up of the crinoidal remains; others are impure and enclose silicified fossils. As might be anticipated, the Crinoids are the most abundant fossils. The silicified ones are found occasionally in place, but usually detached, on the hill-sides with the flinty fragments, and in the soil; silicified *Trochites* of a large size, both circular and oval,—common also to the succeeding member,—are found in many places.

Large *Spirifers* and *Producti* occasionally occur, but excepting perhaps Crinoids, fossils are not abundant, the conditions under which the rocks were deposited not having been favorably to animal life.

List of Species.

1. Cyathophyllum, sp.?
2. Streptelasma, n. sp.
3. Actinocrinus Agassizii, Troost.
4. " urna, "
5. " cornutus, "
6. " Humboldtii, "
7. " Marineri, "
8. " Nashvillensis, "
9. " fibula, "
10. Synbathocrinus Tennesseæ, Troost!
11. Catyllocrinus Tennesseæ, "
12. Cyathocrinus pentasphericus, "
13. " corrugatus, "
14. Conocrinus tuberculosus, " !
15. Agaricocrinus tuberosus, " !
16. Spirifer allied to attenuatus.
17. Producti and other shells not described.

As we approach the topmost strata, the rocks, without affording any well marked limit, gradually run into

20. (*b.*) *Cherty limestone.*—This member though related to the last, differs in being a true limestone, in affording a brick-red soil, in the character of its imbedded masses, and in being much more fossiliferous. The fundamental rock is thick-bedded and impure, of a light blue color; it occurs occasionally in purer beds without flints, but, in the main abounds in reniform nodules of chert and in siliceous layers. The latter, which, by the way, are very characteristic, liberated by the removal of the calcareous matter that contained them, occur very generally on the surface and in the red soil, in rough *friable* masses having a *porous* sandy structure and a light yellow or gray color; they abound in species of the beautiful *Fenestella*, and often in a large undescribed (?) Orthis, as well as in other species.

The strata are sufficiently argillaceous to give the soil a clayey consistence.

A most important economical feature of these rocks is the presence, especially westward, of iron ore which sometimes passes down into the member below. The soil everywhere contains sufficient oxyd of iron to color it deeply.

This member is mostly the surface-rock of the table-lands surrounding the basin, and usually appears a few miles in the rear of the escarpments, increasing in thickness as we approach the mountains on the east, or the hilly ridges of Southern Kentucky on the north and northwest. (§ 6.)

From my own observations, and the best data I can collect, I infer the member to be from 250 to 300 feet thick, making the entire group 450 or 500 feet.

Owing to the present imperfect state of our knowledge of American carboniferous species, it is impossible to give a satisfactory list. The following is presented.

1. Syringopora reticulata, Gold.?
2. Lithostrotion, sp.?
3. Cyathophyllum, sp.?
4. Fenestella retiformis, Schlot.? and other species.
5. Synbathocrinus Tennesseæ, Troost!
6. Agaricocrinus tuberosus, " !
7. Conocrinus tuberculosus, " !
8. Granatocrinus cidariformis.
9. Platycrinus Saffordi, Troost.
10. Productus cora, A. d'Orb. and other sp's.
11. Spirifer, several sp's.
12. Orthis, " "
13. Terebratula serpentina, d. Kon.
14. Pleurotomaria, sp.?
15. Euomphalus, three sp's.
16. Bellerophon, sp.?
17. Acephala, several genera.

Art. XXXVII.—*On the Houghite of Prof. Shepard;* by S. W. Johnson, of the Yale Analytical Laboratory.

Read before the Am. Assoc. for the Advancement of Science, at Albany, Aug. 1851.

On page 314 of the Proceedings of the meeting of this Association held at New Haven last year, occurs a notice of the mineral Houghite by Prof. Shepard. More than two years since I noticed specimens of this mineral from Dr. Hough, and then purposed to examine it. The specimens which were in my possession at the time of the publication of Prof. Shepard's paper, and which furnished the material for my analyses, agree in the main with his description; and it appeared improbable that any chemical species could be made from them as they were exceedingly variable in composition as well as in appearance. It commonly occurs as small imbedded nodules, usually more or less flattened, with the interior dark gray or bluish gray and the exterior white.

Experiment and observation unite in proving that the difference in color between the external and internal portions of these "concretions" is due to difference of composition. The milk-white parts contain *carbonic acid*, the bluish-white portions do not. Further, some specimens are milk-white throughout, while others are almost entirely of a bluish tinge, and semitransparent. The specimens at my command for analysis were uniform in ap-

pearance, but were more or less opake white externally and without exception were pervaded by minute grains of spinel and phlogopite. Some of them presented a portion just within the opake layer, that was transparent and homogeneous: within this, fragments and crystals of spinel predominated. These statements are necessary as a preface to the account of my chemical investigations, after detailing which, the physical properties will be again referred to.

The mineral subjected to analysis, comprised fragments partially opake and partially translucent, as it was almost impossible to procure by separation a homogeneous material. After ignition, it manifests an alkaline reaction, and this, as I have since found, it also does before heating.

As stated by Prof. Shepard, it is decomposable in acids, before and after ignition. A large nodule, slowly dissolves, even in cold acetic acid. Carbonic acid is evolved during solution, and in sufficient quantity to produce a precipitate on passing through baryta water. A residue has always occurred in my experiments, consisting in part of insoluble minerals,—spinel and phlogopite, and also in most cases of silica; and in fact, the mineral has often afforded a well characterized jelly with acids. The acid solution gives with ammonia, in presence of chlorid of ammonium, a copious white precipitate. The filtrate contains only magnesia, or occasionally a trace of potash, possibly from decomposition of phlogopite. The ammonia precipitate, as noticed by Prof. Shepard, yields alumina and a trace of iron to caustic potash, but is not entirely decomposed even by a large excess of it, during protracted digestion at a boiling heat. Following the usual routine of analysis it was repeatedly, and most carefully examined for all the salts and rare earths that can occur in such circumstances, but no evidence of their existence was obtained. It appeared to be a hydrous compound of magnesia and alumina, and upon reference to Gmelin's Handbuch, notice of such a substance was found. By three or four repeated solutions in hydrochloric acid, and precipitations by ammonia, it was completely separated into the two earths, alumina and magnesia; which with water completed the sum of its ingredients.

Previous to entering on the quantitative investigation of this mineral, I made inquiries of Dr. Hough, who resides near the locality, hoping to obtain homogeneous specimens. He could not furnish them, and the following analyses were made without expectation of perfectly accordant results.

In the analysis, carbonic acid was determined, in the usual manner, in a flask furnished with chlorid of calcium and aspirating tubes. Water was expelled by ignition, and collected in chlorid of calcium. The mineral was decomposed in hot hydrochloric acid, the whole evaporated to dryness, redissolved, and filtered;

in the solution, alumina and magnesia were separated by bicarbonate of soda; the magnesia weighed as pyrophosphate, the alumina, as such, after solution and reprecipitation by carbonate of ammonia. The insoluble residue was treated with hot solution of carbonate of soda, to extract silica.

Before subjecting the mineral to analysis, a portion in small fragments, the most homogeneous that could be selected, was used for determining its specific gravity. For this purpose after its weight had been taken, it was boiled in the water in which it was subsequently weighed, as air bubbles adhered to it very pertinaciously. The number 2·175 was obtained; but the mineral was afterward found to contain spinel.

A quantity of the mineral after being pulverized, was placed in a Liebig's drying tube, and exposed in a current of dry air to a heat of 100° C.; it lost water for a long time. The heat was afterward raised to 175° C., and it continued to lose weight for several days. It was finally submitted to the highest temperature admissible in an oil-bath, 280° C. (536° F.), and after more than 100 hours of drying, it ceased to lose weight. As this result had not been foreseen, the original weight of the mineral was not taken; the loss was at least five per cent.

In this dried portion were found

Äl	Ṁg	Ḣ (by diff.)	C̈	insol. (Spinel, &c.)	Silica.
19·743	36·292	24·223	8·458	8·264	3·020=100.

A fresh portion of the mineral including that employed in taking the specific gravity, was carefully intermingled, pulverized and dried over SO_3 *in vacuo*.

Two determinations of carbonic acid gave respectively 6·712 and 8·094 per cent.; mean, 7·380 per cent. Another portion, the only remaining material, was ignited until it ceased to lose weight. It then contained no carbonic acid. The loss was 40·857 pr. ct. It was analyzed with the following results.

Äl	Ṁg		
30·048	55·467	insol. (spinel and mica) 15·196,	Silica, *trace* =100·711

Several water estimations were made, varying from 33 to 41 per cent., but I attach no value to them. If we subtract 7·380 the mean result for carbonic acid from 40·857 the total loss on ignition, we obtain 33·477 as the per-centage of water; rejecting the insoluble minerals and calculating the remaining constituents on 100, the composition stands as follows:

Äl	Ṁg	Ḣ	C̈
23·867	43·839	26·452	5·833 = 99·995

Excluding, in both analyses, all the ingredients but alumina and magnesia, and reducing these to per-centage relations, we find the following numbers.

	1st Analysis.	2d Analysis.	Mean.
Äl	35·238	35·137	35·185
Ṁg	64·763	64·862	64·812

These accordant results indicate the existence of definite relations between these two ingredients. Divison by the equivalents, gives the ratio of 4 of alumina to 19 magnesia, corresponding to alumina 35·15, magnesia 64·85. The ratio of 1 : 5 would require alumina 33·53, magnesia 66·47.

It seems useless to speculate on the constitution of Houghite without new analyses.

Quite recently, I have visited the locality in company with Dr. Hough. It is in the town of Rossie, and near the village of Somerville, in St. Lawrence county, N. Y. The mineral occurs disseminated through white crystalline limestone, at the summit of a slight elevation, near which occurs beds of the Potsdam sandstone. Associated with Houghite are dolomite of variable composition, scapolite of brown and green color, phlogopite, graphite, spinel, and a crystallized pseudomorphous (?) yellow serpentine, in which I have obtained the water and silica percentages of that mineral.

Much of the rock exhibits evidences of atmospheric action. The serpentine in the altered parts has become discolored and so friable as to yield to the pressure of the fingers. The nodules of Houghite are half exposed, easily detached from the rock, and often opake and milk-white throughout.

This altered or bleached appearance in the rock does not occur upon the uppermost surface, as far as I have observed, but along its sides and under portions pendant over a cavity. But not a nodule of Houghite has been found even in the least altered rock that has not presented superficially in some parts a milk-white color.

Among the masses which furnished material for analyses, I found several specimens that exhibited unequivocal evidences of octahedral crystallization, one of which is here represented. Some of them are $\frac{3}{4}$ths of an inch in diameter; they are superficially grooved and contorted, their edges are rounded, and protrude beyond the planes of the faces. In some an appearance occurs, which seems as if it had been produced by a protrusion, near the edge of each plane, leaving a line of depression with reëntering surfaces, corresponding to the lateral edges of a perfect octahedron,

while on the faces, a triangular depression occurs, bounded by the protruded edges of each plane of the crystal. In one nodule there is a gradual transition from the soft and amorphous Houghite, to the hard and regularly terminated spinel. The crystals are occasionally compound.

In another specimen, in Dr. Hough's collection, there were the summits and faces of several perfect octahedrons. The solid angles had the hardness and lustre of spinel; but portions of the faces were destitute of lustre, or only glimmering, from disseminated particles of spinel, and were easily scratched by the knife. This specimen consists of three almost perfect crystals, each about $\frac{3}{4}$ths of an inch in diameter, besides three of smaller size. The whole was imbedded in serpentine and dolomite. These crystals are formed of mixed spinel and Houghite. The spinel seems to predominate on the edges and solid angles; but some of the well defined edges yield to the knife. When a crystal is held so as to reflect light to the eye, it is very easy to distinguish the two minerals. It is seen that they are irregularly disposed, and yet follow certain lines of cleavage which are not parallel, often curved and generally unsymmetrical with the figure of the crystal. They seem free from the milk-white color which is observed in the amorphous masses, and no doubt contain the true specific Houghite. In another large octahedral crystal of regular form, the exterior is whitened and altered to the depth of half a line.

Many interesting facts and speculations have occurred to me in relation to the origin of this mineral. Its association with spinel as well as the similarity to that mineral in the bases in its composition, are facts of great interest. It might appear that they were simultaneously formed, since they occur together, in such intimate mixture, and yet are so well defined. Possibly when the spinel has predominated to a certain extent, or been placed in otherwise favorable conditions, its crystallizing force, in causing it to assume its own peculiar form, has impressed that form on the Houghite, analogous to what has occurred in the Fontainbleau limestone. But there are objections to this view, since spinel, according to the experiments of Ebelmen, is of purely igneous origin, and the circumstances attending its formation are incompatible, as far as we know, with the simultaneous production of a hydrous mineral.

[*Note on the probable Identity of Houghite and Völknerite.*—Mr. Johnson has observed that we cannot obtain from the analyses a satisfactory view of the composition of the mineral, owing to the uncertain results. The analyses are still sufficient to authorize the suggestion that Houghite, when pure and free from carbonic acid, may be identical with the *Völknerite* of Hermann.* Hermann obtained for the Völknerite,

$$\ddot{A}l\ 17{\cdot}65, \quad \dot{M}g\ 38{\cdot}59 \quad \dot{H}\ 43{\cdot}76$$

This gave Hermann for the oxygen of the alumina and magnesia the ratio 1 : 2, [more exactly 1 : 1·84] while the analyses of

* Journ. f. prakt. Chem., xl, 11, and Dana's Mineralogy, 3d edit., p. 201.

Houghite rather favor the ratio 1 : 1½. The approximation shows at least the close relation of the two minerals. As part of the water of constitution was evidently driven off by excessive heat in drying, the per-centage of this ingredient is yet to be ascertained. The grayish mineral forming the interior of the masses is not foliated like Völknerite, but this structure may not be more essential here than it is in gypsum. The nodules are often somewhat fibrous radiated. The presence of carbonic acid in the exterior of the nodules is apparently due to an alteration of the true hydrous mineral, from the action of the carbonic acid of infiltrated waters or the atmosphere. The hydrotalcite of Hochstetter, which Hermann refers to Völknerite, afforded 10·54 p. c. of carbonic acid.*

The mineral has probably resulted from the alteration of spinel, judging from the many specimens the writer has seen. There is a passage from the perfect octahedrons with sharp edges, to those that are uneven and rounded as if by corrosion from chemical action, and from these to the flattened nodule; and the nodules are such forms as would result from a softening and pressure accompanying the metamorphic change, together with the crystallizing or semi-crystallization of the new mineral.

J. D. D.]

ART. XXXVIII.—*On some of the Thermal Waters of Asia Minor;* by Dr. J. LAWRENCE SMITH, of New Orleans, Prof. Chem. in the University of Louisiana.—Part II. *Waters of Yalova, Hierapolis, Eski-shehr, Troy, Mitylene and Tiberias.*

Thermal Waters of Yalova.†

THE shortest way of reaching the springs of Yalova is by landing on the south side of the Gulf of Nicomedia, near to *Angori,* (three hours distant from Constantinople by steamer,) and proceeding along a beautiful plain, that gradually narrows until terminating in a valley closely shut in by hills. The springs in question are situated in this valley, about six miles from the sea; they are at the foot of a hill, which on the southwest closes in the valley of Yalova and are known in the country by various names, as *Couri-Hamam, Dagh-Hamam,* &c.

On the road that approaches the springs, there are extensive remains of the foundations of old Roman and Grecian buildings, and still nearer, the remains are more perfect, in the form of arches,

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* See Dana's Mineralogy, p. 201.

† The locality of these waters is described very fully as it is but little known, being seldom visited by travellers.

aqueducts, baths, &c. Their extent gives evidence of the celebrity they enjoyed in former times. The styles of their architecture belong to different periods. The remains of the brick edifices are evidently of the period of the Lower Empire, for on many of the bricks are to be found an impress of the cross, and Latin words written in Greek letters. To judge from the form of these letters, particularly the epsilons, sigmas and omegas, one is led to believe that they date from the Justinian age. The massive stone arches, which support the vault under which the waters rise, seem to have been constructed by the Romans. Their structure presents nothing which opposes the idea received by the inhabitants of the surrounding villages, namely, that they were constructed during the reign of Constantine the Great. And what seems to sustain this hypothesis, is, the popular legend that the mother of Constantine was indebted to these waters at one period of her life, for her restoration to health; and from this fact (according to the authority of the celebrated archæologist, the Patriarch of Constantius) Yalova was formerly called Helenapolis.

In want of more exact data we may cite as sustaining this supposition, the custom of the Greek villagers of the neighborhood, kept up for many centuries, of assembling at these baths on the anniversary of the *fêtes* of St. Constantine and St. Helena, to celebrate the virtue of these waters. Von Hammer in his history of the Turkish Empire, alludes to this place in the following words: "Some leagues from *Cara-Mursal* on the south side of the Gulf of Nicomedia, there exist the baths of Yalova (ancient Sergla or Trepanon). This place was adorned with a great number of palaces and hospitals by the Empress Helen, whose father had kept an inn there. This place was afterwards raised to the rank of a city by Constantine, the founder of the Byzantine empire, and called Helenapolis in honor of his mother. It was to this place that the first army of the crusaders, conducted by Peter the hermit and Gautier *sans-avoir*, took refuge after being routed near Nice. It was here also that the Saracens constructed pyramids and towers with human bones. Helenapolis has been at all times celebrated for its thermal waters. Near their source is to be seen the tomb of an *Abdal*, that is, an enthusiastic dervish, who armed with a wooden sword undertook at the head of a body of Mussulmans to conquer this city."

There are several ancient authors who allude to these springs, among whom are Ammianus, Marcellinus, Mela, and Anna Commenus.

Yalova, which is now but a small village, was formerly the place of debarkation for the inhabitants of the celebrated cities of Nicomedia, of Nicea, and of the numerous cities of Bithynia, who visited these springs. The port of Couri, whose antiquity is

indicated by several Greek inscriptions, was probably, as now, frequented by those coming from Constantinople and other cities of the Propontide.

After the fall of the Roman empire, these baths went to ruin, and were almost forgotten; nevertheless the reservoirs and aqueducts remain as in the time of the Lower Empire. It is only a few years since an Armenian banker purchased the place and constructed houses for the reception of the sick.

These waters have at least *nine* sources. They flow from the sides and bottom of a hill, rising through a sandy bottom accompanied with bubbles of gas, and differ but little in their temperature and composition. The character of the surrounding rocks is not easily made out; I am inclined to refer them, from my observations higher up the gulf, to the older tertiary. The waters in their course leave not the slightest deposit, so that the ancient aqueducts have never become obstructed.

According to the accepted classification, the mineral waters of Yalova belong to the *hot sulphurous waters*. They have at their source a very slight odor of sulphuretted hydrogen, but the quantity is so small, either in the water or the gas, that it could not be estimated. The temperature of the waters is from 151° to 156° Fah., and varies but little with the changes of the atmospheric temperature. The water is limpid and transparent, and has the specific gravity 1·00115.

The gas which escapes at the source gave on analysis,

Nitrogen,	- - -	97 per ct.
Oxygen,	- - -	3

One litre of the water gave 1·461 grammes of solid matter. —The same quantity of water contains in grammes,

Sulphuric acid,	. .	·690	Magnesia, . . . ·002
Chlorine,	. . .	·086	Alumina, . . . *trace*
Soda,	. . . .	·393	Silica, ... ·035
Lime,	. . . .	·208	

Combined in the following manner:—

Sulphate of soda,	. .	·807	Sulphate of magnesia, . ·005
Sulphate of lime,	. .	·414	Sulphate of alumina, . *trace*
Chlorid of sodium,	.	·072	Silica, ... ·035
Chlorid of calcium,	.	·068	

The composition of these waters resembles that of the Bath waters of England, the latter however not being of so high a temperature. They act powerfully on the nervous system and on the secretions and excretions, particularly those of the skin; which renders them so efficient in rheumatism, gout, &c.

Thermal Waters of Hierapolis.

The ruins of the ancient city of Hierapolis are among the most interesting in the southwestern part of Asia Minor. The place is situated about six miles from Laodicea (one of the seven churches) and about one hundred and ten miles from Smyrna. The site is seen for many miles before it is reached, as it rises abruptly from the north side of an extensive plain, and the sides of the hill are covered with an incrustation of dazzling whiteness for upwards of a mile in length, and from this it has received its present name, Pambuk-kelesey, (*cotton castle.*)

This place was much admired in former times, if we are to judge from the inscriptions still to be seen on different parts of the ruins, to the following effect. "Hail, golden city, Hierapolis; the spot to be preferred before any in wide Asia; revered for the rill of the nymphs, adorned with splendor;" the people, in some of these inscriptions, are styled, "the most splendid," and the senate, "the most powerful."

It is a place well known to travellers in this part of the world, and therefore I shall confine myself strictly to what concerns its thermal waters, which have ever been its principal object of note, as evinced by the extensive ruins of baths. In fact the very hill upon which the city stands owes its formation to the deposition of carbonate of lime from these waters, and it now rises upwards of a hundred feet above the plain with a width of about six hundred feet. Immediately behind the city, rises another set of hills of calcareous rock, from which flow the waters in question; they first enter a large pool in front of the theatre, and from this the water flows in numerous little streams that course in channels made by incrustations from the water. The amount of water is very great, and it is so highly charged with carbonate of lime, as to incrust all bodies that it comes in contact with, and it takes place so rapidly that the concretion does not possess great solidity, and frequently has a granular form resembling driven snow.

It is this incrustation, as I before said, which gives to the immediate site of the city its remarkable character. In some places as the waters flow over the steeply inclined sides of the hill, it forms a succession of terraces at regular distances, that require but little effort of the imagination to liken to an amphitheatre with its marble seats. At other places, it flows over the precipitous sides sixty or seventy feet high, and one or two hundred feet wide, incrusting the precipice with a snow-white sheet which might be likened to a consolidated cataract, and what adds to the delusion, at the base the incrustations have accumulated an irregular mass not unlike foam. This petrified stream extends several hundred feet into the plain. It has formed walls and

dikes, and incrusts the grass and vegetation that it flows over, and many of the tufts of grass, in perfect verdure, are thickly incrusted near the roots with this white carbonate of lime.

The channels that conduct the water through the city are made by deposits from these waters; many of them are very deep and almost arched over. The incrustations in and about the city have elevated the level of it some fifteen or twenty feet, since its destruction. Strabo tells us, that in his day the people of this city conducted these waters into their gardens or other places where they desired to form a wall, and in a short time they obtained fences of a single stone, so rapid was the deposition. The road which leads from the plain to the city is a causeway which is formed entirely from the water.

Physical Properties.—The water is of remarkable transparency, and remains so after being kept for any length of time. Having lost my thermometer the day before arriving at this source, I was unable to ascertain its exact temperature. I judged it to be about 130° Fah. Specific gravity, 1·00143.

Chemical Properties.—Solid contents in one litre, 1·934 grammes. One litre contains in grammes:

Carbonic acid, free, .	·352	Potash, . . .	*trace*
Carbonic acid, fixed, .	·462	Lime, ...	·589
Sulphuric acid, . .	·541	Magnesia, . . .	·164
Chlorine, ...	·012	Silica, ...	·008
Soda, ...	·182	Phosphoric acid, . .	·005

The combination of acids and bases may be represented in the following manner.

Bi-carbonate of soda, .	·078	Sulphate of lime, . . ·119
Bi-carbonate of lime, .	1·368	Sulphate of magnesia, . ·431
Bi-carbonate of magnesia,	·041	Phosphate of lime, . ·012
Chlorid of calcium, .	·020	Silica, ... ·008
Sulphate of soda, . .	·341	

The *incrustation* of the spring was analyzed; it is remarkably white, and almost pure carbonate of lime. The composition is as follows.

Carbonate of lime, . . .	98·2
Silica, ...	00·6
Magnesia, Phosphate of lime, Fluorid of calcium, . . .	1·2=100·0

At the present day these waters are not used, and the neighboring country is quite deserted, with the exception of a miserable village of some half dozen huts. In former times, however, beside the use of this water for the baths, it was greatly in repute

among the dyers in a purple color made from a kind of root, and owing to the remarkable adaptation of this water for that purpose, the tint obtained is said to have rivalled the more costly purple, and to have constituted the principal source of riches to the city. The company of dyers is alluded to in the inscription on a square building among the sepulchres. These waters also seem to have possessed medical virtues, if we are to judge from some of their medals, on which you find Apollo (the tutelar deity of Hierapolis) with Æsculapius and Hygeia.

Strabo alludes to a circumstance connected with these waters that I inquired into while there, but without success. It is the existence of what that author calls a *Plutonium*, described as an opening about the size of a man in the side of the hill, with a kind of enclosure of half an acre in front of it; from the opening there issued constantly a dark vapor, that filled the enclosure in front of it. He states that all animals entering this enclosure became suffocated, but that the sacred eunuchs who attended in the temples could enter with impunity.

I sought to discover this *plutonium* but without success, it was doubtless an opening in the rock, from which issued a mixture of carbonic acid and vapor of water, that has subsequently become obstructed.

Thermal Waters of Eski-Shehr.

Eski Shehr is the ancient Dorylæum, the plains of which are very extensive. It is mentioned by the Byzantine writers as the field of the first battles between the soldiers of the Eastern empire and the Turks. It is situated on the river Pursceck or Thymbius, which empties into the Sangarius, that flows into the Black Sea, and is equidistant from that sea and the sea of Marmora, being a little over one hundred miles from each.

Eski-Shehr is a city of some importance to the Turks, and it is from here that Europe derives the greater portion of that mineral called Meerschaum, used in making pipes.

In a certain quarter of this city, by excavating to the depth of a few feet, hot water is obtained, which is a matter of great annoyance to the inhabitants, as they can have no wells of drinking water. It is in this quarter that are situated the celebrated hot baths, doubtless used for more than two thousand years, with such change in structure as time and the habits of the people required. There is here a large excavation sixty or eighty feet square, closed in with stone and roofed over; its depth I did not measure, but am told that it is twelve or fifteen feet. The water arrives from many sources at the bottom of this reservoir.

The reservoir was made by the Greeks and repaired some years ago by the Turks. The amount of water furnished is

very great, and forms half the water used in turning a mill in the neighborhood.

The water is allowed to flow from the great reservoir into a large Turkish bath, as well as from different hydrants for the purpose of washing dyed stuffs, &c.

Physical Properties.—This water is clear and transparent, and when cold it is very agreeable to the taste; no gas escapes from it, nor is there any deposit, even after very long repose. Temperature 119° Fah. Specific gravity 1·00017.

Chemical Composition.—The solid contents in one litre ·260 grammes. One litre of the water contains in grammes—

Carbonic acid, free, .	·118	Soda with a little potash,	·119
Carbonic acid, fixed, .	·195	Lime, ...	·040
Sulphuric acid, . .	·030	Silica, ...	·008
Chlorine, . . .	*trace*		

Combined as follows:—

Bi-carbonate of soda, .	·219	Sulphate of lime, .	·029
Bi-carbonate of lime, .	·078	Chlorid of calcium, .	*trace*
Sulphate of soda, .	·021	Silica, . . .	·008

As is seen by the analysis, this water is remarkably free from solid matter, nor is it supposed by the inhabitants of the country in its neighborhood, to possess any other than the ordinary properties of water.

The geological character of the contiguous country has nothing in it that would induce one to suspect the existence of such abundant sources of warm water. The plain of *Eski-Shehr* appears to be one of those extensive lacustrine regions so common in the western portion of Asia Minor; the deposits consist of a consolidated breccia. Imbedded we find the rocks of the neighboring mountains, as well as the Meerschaum or silicate of magnesia, so extensivly worked for exportation. Thermal waters are obtained in numerous parts of the plain as well as at Eski-Shehr.

Thermal Waters of Troy.

Near the plains in which are supposed to have been situated the ancient city of Troy, are numerous sources of thermal waters, of several of which I procured specimens; only two, however, have been analyzed, the others not having arrived at my laboratory. These springs are those alluded to by Homer, and they have enjoyed more or less reputation from the time of the Trojans to the present date. The two that I have examined are saline and their sources near each other. Analysis shows them to be identical. The physical properties will be alluded to when the other waters from this locality have been examined.

Chemical Composition.—One litre contains of solid matter 21·301 grammes. The same quantity of water has in its composition

Carbonic acid, fixed, .	·0595	Lime, . . .	1·4000
Sulphuric acid, . .	·0680	Magnesia, . . .	0·3012
Chlorine, . . .	12·8000	Oxyd of iron, . .	*trace*
Bromine, . . .	*trace*	Silica, . . .	0·0600
Soda, . . .	9·2110		

Combined as follows:—

Carbonate of lime, .	·1225	Chlorid of magnesium,	·7031
Sulphate of soda, .	·0607	Bromid of magnesium,	*trace*
Sulphate of lime, .	·0540	Chlorid of iron, .	*trace*
Chlorid of sodium, .	17·4450	Silica, . . .	·0600
Chlorid of calcium, .	2·5078		

Thermal Waters of Mitylene.

On this island, the ancient Lesbos, there are several warm springs, and much of the geological structure of the place is volcanic. I visited two of the springs; the first is near to the village of Mitylene, and immediately on the shores of the gulf of Olives, it is called *Kelemyeh Oulinjah*, and there are two baths attached to it.

Kelemyeh Oulinjah source.—The water is clear, and flows without leaving a deposit. Its temperature is 102° Fah. (atmosphere at 77°), and when cold there is nothing marked in its taste.

Chemical Composition.—There are 1·250 grammes of solid matter in a litre of the water which contains the following ingredients in grammes.

Carbonic acid, free, .	·155	Soda, ...	·278
Carbonic acid, fixed, .	·075	Lime, ...	·152
Sulphuric acid, . .	·040	Magnesia, . . .	·070
Chlorine, . . .	·570	Silica, ...	·015

Combined as follows:—

Bi-carbonate of lime, .	·2450	Chlorid of calcium, .	·0865
Sulphate of soda, .	·0357	Chlorid of magnesium,	·1628
Sulphate of lime, .	·0330	Silica, . . .	·0150
Chlorid of sodium, .	·6510		

The other source visited on the island of Mitylene is about six miles north of the village, and is called *Touzla;* there are baths attached to it, and the waters are strongly saline.

Touzla source, (saline.)—*Physical Properties.*—The water does not flow clear, being more or less tinged with yellow produced by some organic acid in combination with lime. This deposit is seen to mark the course of the water as it flows down

the beach into the sea which is very near to it. Temperature of the water 117° Fah. (atmosphere at 76°.) Sp. gr. 1·0263.

Chemical Composition.—There are 34·520 grammes of solid matter in a litre of the water which contains the following ingredients in grammes:—

Carbonic acid, fixed, .	·050	Lime, . . .	2·534
Sulphuric acid, . .	1·648	Magnesia, . . .	0·110
Chlorine, . . .	18·440	Alumina, . . .	0·012
Bromine, minute quantity not estimated.		Iron, ...	0·003
		Soda, ...	14·858

Combined as follows:—

Carbonate of lime, .	·0912	Chlorid of calcium, .	2·0040
Sulphate of soda, .	1·4625	Chlorid of magnesium,	0·2023
Sulphate of lime, .	1·3000	Carbonate of iron, .	0·0038
Sulphate of alumina, .	0·0221	Bromid of magnesium,	minute quantity.
Chlorid of sodium, .	28·0260		

There are several other sources of thermal water in various parts of this island; the one reputed to have the greatest temperature is about eighteen miles from the latter, and called *Fezilkeh;* this source I could not visit, and can therefore say nothing of it from personal examination. There is yet one other source that I will allude to, the

Tiberiad Thermal Waters.

The source of these waters is on the border of the sea of Galilee and within a mile of the city of Tiberias, of the solid structure of which, repeated earthquakes have left but little. The surrounding country show marked evidence of extensive volcanic action.

There are several sources at the place I visited, but they seem to vary little from each other. They flow into Turkish baths, and from them pass into the sea, on their way leaving a slight yellow deposit which is doubtless, as in many of these waters, a crenate of lime.

Their temperature was not accurately ascertained for want of a thermometer, but I should consider it about 120° Fah.

Chemical Composition.—In one litre 23·540 grammes of solid matter. The same quantity of water furnished in grammes:

Carbonic acid, fixed, .	·006	Lime, . . .	·443
Sulphuric acid, . .	·197	Magnesia, . . .	·119
Chlorine, . . .	13·989	Silica, . . .	·006
Soda, ...	8·751		

Combined as follows:—

Sulphate of soda, .	·0620	Chlorid of calcium, .	·7801
Sulphate of lime, .	·0386	Chlorid of magnesium,	·1850
Sulphate of magnesia,	·0151	Silica, . . .	·0060
Chlorid of sodium, .	22·2330	Carbonate of lime, .	·0106

The quantity of water brought away was too small to examine for the presence of bromine.

This is the last of the thermal waters of Asia Minor which have been examined; there are a few others that may yet reach me, when the composition will be made known as soon as examined.

Cause of the Thermal Waters in Western Asia Minor.

The cause of the abundance of warm springs in this quarter of the globe, in all formations from the alluvial to the oldest rocks, is doubtless owing to the extensive igneous action within no great depth beneath the surface of the country; a fact evinced by the frequency of earthquakes, but more especially by their extent; for they almost invariably extend from one end of it to the other, as well as to the neighboring islands.

Neither time nor change of government has contributed so much to the destruction of the hundreds of magnificent cities which once covered this country, as the desolating influence of the earthquake, and many are the cities that now exist, which have been prostrated over and over again, and rebuilt, each time in diminished splendor, until at last they are little better than collections of huts when contrasted with their original condition. All the country at the present day seems to be as much subject to them as formerly.

The only part of Western Asia Minor where phenomena are seen strictly analogous to those of active volcanoes, is in the *Catacecaumene* or burnt district, situated in Lydia, about one hundred miles east of Smyrna. Numbers of volcanic cones exist in the neighborhood of *Koola*, of many of which the craters are quite distinct, especially the one called *Kaplar Alan*, which has a perfect crater about half a mile in circumference, and two or three hundred feet deep. The extent of this region is some twenty miles long by eight broad. We have no record of any activity in these volcanoes, and Strabo described them in his day quite as they are now, and the Turks give to Satan the full credit of having created such a black parched-up district. My object at the present time is merely to mention this district, as a full description of it enters into a paper on the earthquakes and volcanoes of Asia Minor, that I propose publishing at some future time; it is brought forward now merely to show what this volcanic centre has to do with the thermal springs just described.

Remarks on the occurrence of Nitrogen in Thermal Waters.—The only substance connected with these waters that I shall allude to, is the nitrogen contained in the gas accompanying many of them, and in some instances constituting almost the entire gaseous product, as in the case of the springs of Yalova. This singular fact attracted my attention several years ago, while

examining into the gaseous products of various springs, and I then ascertained that the gas was found especially with warm springs; the nitrogen, when found accompanied with oxygen, existed in proportions much greater than in the atmosphere, and in numerous instances it was almost pure. The question naturally arises, whence comes this nitrogen? and as we know of no other natural source of nitrogen than the atmosphere, it occurs to the mind that there is a source of the gas in the thermal waters, which, before they pass to the heated substrata, absorb a certain amount of air; the oxygen of the air contained in the water combines with the rocks and minerals, or is taken up by some de-oxydizing agent in the waters, which, as they return to the surface naturally bring the nitrogen of the air freed of all or most of its oxygen.

This explanation, which appears so natural, does not, however, account for the fact, and I have been obliged to abandon it. Did the nitrogen in these waters occur in such small quantities, as we might suppose to have been absorbed by water, the explanation would hold good; but the fact in the case of the springs at Yalova and many other sources, is, that the gas, which is nearly pure, bubbles up in *great abundance*. Again, if the nitrogen evolved by springs be simply such as the water absorbs before penetrating the surface of the earth, how does it happen that this gas escapes from springs of ordinary temperature? For it is reasonable to suppose that the water having once taken into solution a gas, will not give it out except by heat or the presence of a large amount of saline matter, neither of which occur to explain the evolution of nitrogen gas from certain springs.

Feeling thus satisfied that the nitrogen in the gaseous products of springs is not owing to its absorption from the atmosphere, its origin has been sought for elsewhere, but without success, and I am constrained to believe that nitrogen is one of those elements stored up in the interior of the earth, in more or less abundance, either pure or combined, and frequently finds its way to the surface through those fissures by which mineral waters are conducted. Its more frequent occurrence with thermal waters is doubtless owing to the greater depth from which the latter come.

After all, however, that has been said, we must acknowledge the explanation imperfect, and as only furnishing another evidence of the difficulty of learning anything of the origin or uses of this singular substance, nitrogen in its elementary state.

On the Analysis of these waters, particularly with reference to the Silica and Alkalies.

The general method of analysis adopted, differed but little from that usually employed; and the construction of the salts out of the acids and bases has been made entirely from the dictates of my judgment in the matter.

The examination of the silica attracted considerable attention, from the fact that we are in the habit of always estimating it as uncombined silica, even when found in alkaline waters. Although my researches are sufficient to prove to my mind the inaccuracy of this, still I have not thought proper in this paper to deviate from the rule generally adopted, leaving it to more extended research to decide the point.

In the analysis of the waters of Broosa, nearly all of which are alkaline, the following fact has been observed; that on concentrating a considerable quantity of the water to a small bulk, all the carbonate of lime is precipitated and a portion of the silica (whether in combination with lime or not is not yet decided); but a large portion of the same still remains in solution, as well as some lime, although the water is alkaline with an excess of carbonate of soda. The silica is in such quantity that it could remain only in solution in combination with an alkali, in fact there is a silicate of soda and lime present.

The question here arises whether the silica was in a state of combination before the water was concentrated, or is it a result that has taken place during the evaporation; this question can only be decided by more extended investigation.

The observation of the above fact has led me to adopt the following method of estimating the silica in mineral waters. Take a certain quantity of the water, evaporate almost to dryness, add hydrochloric acid, a little more than is required to saturate the carbonates present; continue to evaporate to complete dryness, and then add water acidulated with a little hydrochloric acid, filter and wash the silica that remans on the filter; in this way we are sure to have the silica perfectly free from any silicate.

The method adopted for estimating the alkalies will be mentioned in a few words, as more details of it will be given in a paper devoted especially to that subject, the method has particular reference to the separation of the alkalies from magnesia.

Take the solution filtered from the silica, evaporate to dryness to drive off the excess of acid, add a little water to redissolve, then add pure lime water and filter, when the chlorids of the alkaline metals and calcium with excess of lime will pass through, the magnesia, alumina, oxyd of iron, &c., remaining on the filter. Separate the lime with carbonate of ammonia, or still better with oxalate of ammonia, evaporate to dryness, and heat to drive off the ammoniacal salts, when nothing but the chlorids of alkaline metals will be left which can be separated in the ordinary way.

This completes the description of all the thermal waters of Asia Minor which have as yet come under my notice, with the observations that the investigation have given rise to.

Art. XXXIX.—*On the Preservation of Animal Substances;* by Henry Goadby, M.D., F.L.S., formerly Dissector of Minute Anatomy to the Royal College of Surgeons of England.

In the preserving fluids that I use, and which are known by my name, the following ingredients occur, viz.: rock salt, alum, corrosive sublimate, and the white oxyd of arsenic, or arsenious acid.

These materials are never all employed at one time, and they should be used judiciously, to prevent the contingency of *destroying*, rather than *preserving* specimens of Natural History.

To this end, I think it desirable to describe the *properties* of the materials respectively before giving the necessary formulæ for the fluids.

Rock (or bay) salt is very preservative, and will maintain the characteristics of all tissues unimpaired, better than any other agent with which I am acquainted, provided the *strength* be well regulated; and I make much greater use of the purely saline, or B fluid, than of any other.

Alum possesses very important conservative properties; it is *astringent*, coagulates albumen to some extent, rendering transparent tissues opake in proportion to the volume of alum brought in contact with them; but it *destroys the carbonate of lime*, converting it into the insoluble sulphate. The aluminous, or A, 2, fluid, however, is a very valuable composition; and to it I owe many important preparations, which may be found both in my own possession, and in the Hunterian Museum of the Royal College of Surgeons, of England, and which could never have been made without its assistance.

Alum *combines* with animal tissues so perfectly, that it cannot be dissolved out of them by long continued maceration in water. Whenever it is considered necessary to use the aluminous fluids either to give form, and support, to an animal, or any part of an animal, or a delicate tissue, by reason of its astringent property, or to render diaphanous animals or tissues opake enough to be visible, *the excess of alum* should be washed away with water, and the animal or whatever it be, with few exceptions, removed from the aluminous, and preserved permanently in the B fluid. It should be borne constantly in mind that the effect of fresh volumes of the aluminous fluid should be cautiously watched, lest the alum produce mischievous results; but with care, it may even be used to the full extent of its valuable properties on the soft parts of an animal enclosed in a shell of carbonate of lime, or otherwise possessing that earth, for the muscular, nervous, and other soft tissues, will be much sooner affected by the action of the alum than the denser tissues containing earthy matter. It

will hence be seen that the aluminous fluid is not of universal application.

Corrosive sublimate is also astringent, and the coagulator of albumen; the intention of its application is not for the sake of either of these properties, but simply to prevent vegetation *growing in the fluids* respectively. But inasmuch as albumen takes from corrosive sublimate a portion of its chlorine, and thus converts it into calomel, and as all animal tissues are more or less albuminous, the propriety of using it at all, may well be questioned. In places where the sporules of fungi abound, as in the store-rooms of large museums, not even the presence of corrosive sublimate can prevent them from *growing upon the surface* of *either* of my preserving fluids, if they contain animal matter of any kind and are in *open* vessels, i. e., not hermetically sealed; but, in a long experience of this fact, I am bound to say that, although I have had open jars, dishes, and other vessels containing dissections of animals waiting their turn to be mounted permanently as preparations, in which the surface of the fluid has been covered during the summer months with vegetation of considerable substance, and which has continued to increase, and flourish magnificently for weeks, yet, I have never known it to *descend* into the fluid, or affect the dissections (provided they were well covered with fluid) in any way. Indeed, either of these fluids will preserve plants, as easily, and certainly, as they preserve animals; and were the fungus to grow *into* the fluid, it would die, and be preserved. Neither have I at any time, during fourteen years experience of preparations made by the use of my fluids, and contained, and sealed down, in the several forms of vessels and cells, also of my invention, ever found a particle of vegetation in a single preparation; and during the last six years I have been using the fluids, both for permanent preparations, and stores, without the addition of corrosive sublimate, and always with satisfactory results. I believe, therefore, that the corrosive sublimate may be safely left out, although I shall include it in the recipes of the fluids.

As arsenic acts upon glass and glass vessels, by combining with the lead, and for other reasons, it cannot be employed for preparations that are desired to be permanent. I have made a few such attempts, but they have all ended in failure. Arsenic possesses the power of softening animal tissues to a most remarkable extent, and this property has no limit.

A few years ago I was desired by the examiners in Anatomy, of the University of London, to preserve a body during the summer season for their examinations in the autumn. Desiring to retain the tissues severally in as natural a state as possible, I added arsenic to the B fluid. For some months, nothing could exceed the success of this experiment, and if I had changed the

fluid, and substituted B fluid without arsenic, I believe the body would have been permanently preserved. It was neglected, however, in this respect, although I watched it with some solicitude until, after the lapse of rather more than twelve months, I found the entire body (with the exception of the bones) reduced to the condition and appearance of decomposing size, except that it remained perfectly sweet. I have made a number of experiments, with the like results. I have seen the characters of muscle, tendon, nerve, &c., gradually disappearing, until nothing but a glairy fluid remained, but which was always *perfectly sweet.*

The softening property is that for which I employ arsenic; either to recover animals that have been hardened, and corrugated in alcohol, or to enable me to proceed with elaborate dissections of nerves, which must necessarily be tedious. My friend Dr. T. S. Beck of London could never have made such a display of the nerves of the uterus—the finest dissection of nerves in the human subject that I believe has ever been made—without the aid of arsenic, which was never allowed to do mischief, occasionally washed away, then renewed, and so on; and the nerves, under its well regulated influence were as tough as copper wire, and although very delicate in appearance, would bear pulling and stretching with impunity.

The aluminous fluids I originally designated by the letter A, and I called them 1 or 2 as the same weight of the ingredients were dissolved, either in one quart of water or two quarts; they are thus made.

A, 2

Rock salt, ...	4 ounces.
Alum, ...	2 ounces.
Corrosive sublimate, ...	4 grains.
Boiling water, ...	2 quarts.*

The A1 only differs from the above in having half the quantity of corrosive sublimate, and water. It is very rarely used, being generally too astringent.

B

Rock salt, ...	8 ounces.
Corrosive sublimate, ...	2 grains.
Boiling water, ...	1 quart.

The corrosive sublimate must never exceed, under any circumstances two grains per quart of water; otherwise there will be in time a white precipitate on the preparation that cannot be removed, and which will greatly disfigure it.

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* The *imperial quart* of 40 ounces is intended to be understood throughout this paper.

When the B fluid is made according to the above recipe, its specific gravity at a temperature of 60° will be 1·100, and with it, terrestrial and fresh-water animals can be well preserved.

For marine animals the strength of the fluid must be increased by the addition of salt to 1·148, otherwise they will be decomposed. A great number of marine animals in the first stages of the preserving process require alum, but it must be cautiously used, and carefully watched, and as soon as it has done all that is required of it, the animal should be well washed in clean water and placed in the B fluid. There is no objection to frequent contact with alum, if necessary, provided the process be conducted on the principle here laid down.

The Arsenical Fluid.—When I employ arsenic for its *softening* properties, I use it alone, unless the process is likely to occupy much time, and in that case, I combine it with the B fluid, in the following proportions, and call it *C*: B fluid, as directed above, arsenic 20 grains. Arsenic can no more be trusted with carbonate of lime, than alum; and if it be desirable to employ it on any molluscous animal the creature should be removed from its shell prior to its introduction to arsenic. The solutions of arsenic that I have employed differ in strength from 20 grains to 60 grains to a pint of water, (imperial measure, 20 ounces) or to the pint of B fluid. It is not easy to dissolve this mineral, and the only plan which I have found successful, is to place the quantity of arsenic to be dissolved in a Florence oil flask with half a pint of water, apply a spirit lamp, and boil till the whole be dissolved, it can then be diluted by the addition, either of more water, or preserving fluid. I may mention one singular fact of preservation by this fluid, no less of the animal, than (which is most important) its color.

Upwards of six years ago my son collected for me several specimens of the larvæ of Cossus ligniperda, the peculiar color of which had never been preserved. In alcoholic fluid, of any strength, it turns quite black, which is a common result of the application of spirit for preserving caterpillars; in addition, most insect colors are soluble in alcohol.

The specimens included larvæ of the first and second year, and one fine sample of a three-year larva about to change to a chrysalis. Of the former specimens I preserved some in the A 2, and the rest in the B fluid, and placed the last in a solution of arsenic. The aluminous fluid has hardened and disfigured the caterpillars nearly as much as spirit would have done; they are softer, and in a better state for dissecting, in the B fluid; but they have lost all their rosy redness of color in both fluids, and are partially black.

It was reserved for the arsenic to give me one caterpillar so beautifully preserved that all its characteristic color, even to the

delicate tint, is maintained to this time. I *believe* that the interior has not been destroyed by the softening tendency of arsenic before alluded to, because, if so, I think there would be considerable deposit in the fluid, which has not occurred; neither in that case would the insect retain its roundness, and fullness, but on the contrary become flaccid by the removal of those tissues (muscles) that give form to the integument. As this caterpillar had been secluded from the operation of light (the fruitful agent for destroying color in animals) for more than twelve months, I determined to try the effect of constant exposure, to which I submitted it for three years in England, and for six months in this country; its beauty is still unimpaired. As it is a sole specimen, and I am not likely to obtain another, I am unwilling to dissect it.

I have been particular in speaking of the successful application of arsenic in the preservation of *color* in this caterpillar, because I believe it is of some importance. It is most interesting to collect the larvæ of Lepidopterous and other insects, as far as possible, but they lose much value for the purpose of instruction and for collections, unless their color can be permanently preserved; and I have great hopes that the fluid which has proved so eminently successful in the instance of the caterpillar of the goat-moth, which takes on the described blackness a very few days after death, in every other preserving fluid, may be equally efficacious in the preservation of color, in the other species.

Mode of using the Preserving Fluids.—A knowledge of the proper methods of using the fluids is essential to success, for in other hands than my own, they have led to the destruction rather than the preservation of specimens. Men have constantly treated my preserving fluids as though they were using spirit, entirely overlooking one very important consideration, namely, the vast difference between their specific gravity and that of alcohol. In the latter, we have a fluid so light that every animal is *heavier*, and will instantly sink in it; the conditions are exactly reversed in the former case, where every animal, from an animalcule to an elephant, is lighter, and will float upon either of them.

Neither of my fluids (always excepting the arsenical) *can be employed of full strength in the first instance*, and any thing to be preserved in them should undergo previous maceration in clean water, to which, after a time, preserving fluid may be added until the animal rises to the surface. The fluid and the water must be intimately mixed mechanically, or the water will rise through the denser fluid, and retain its integrity for a long time.

The animal will insensibly absorb, and become saturated with, the *ingredients* of the preserving fluid, but in a state of considerable dilution; the strength of the fluid must now be gradually in-

creased, and intimately mixed, until the animal again rise, and in time it will become saturated with this denser fluid. In many instances it is advisable to keep the animal forcibly at the bottom of the vessel in which it is being preserved *by weights*, and this is particularly necessary in hot weather when the preserving process should be expedited with all the speed that is consistent with safety. It is easy to ascertain if the animal be saturated with the fluid by removing the weights, and in that case, to go on increasing the strength of the fluid: in fine, success depends on carrying out the laws of endosmose, and exosmose. The diluted fluid used in the first stages should be thrown away, and frequently renewed, as, being replete with animal fluids, it contains within itself the elements of decomposition, and increases the difculty of obtaining ultimate success. This remark, however, applies less to the aluminous, than to the B fluid, as in the former, the coloring matter, and animal deposits of all kinds so abundantly seen when spirit is used and which occasions the steady and constant discoloration of that fluid, for, in some cases, many years, and which so generally tends to the disfigurement of preparations in museums is altogether *insoluble* from the instant it, or they, come in contact with alum; and for this very important reason alum may be almost *always* used in the early stage of preservation, the former cautions on this subject being strictly attended to. Preservation of animals by means of these fluids, then, can only be accomplished by the daily addition of fluid until the creature be saturated with the fluid of the full strength indicated. Nor should the solicitude of the operator end immediately at this point, as it will be necessary occasionally to renew the fluid and often to test its strength. To shorten this species of labor I long ago procured a glass jar, or tube, two and a half inches long, and three-fourths of an inch wide, with a flat bottom, to be used as a proof glass; I then adjusted some specific gravity bubbles so accurately that they *rise very slowly* in the fluid, the precise strength of which they are intended to indicate; if the fluid be weaker than exact strength, they fall to the bottom, and there remain; if stronger, they quickly rise. They are marked on the top A 1, A2, B, S, the latter indicating a *saturated* solution of rock salt with which it is convenient to increase the daily strength of the B fluid in the manner already described.

By pouring a little fluid into the small proof glass, and applying a bubble as the test of strength of the fluid that has been employed, the operator will instantly learn, not the exact strength, (which is unnecessary,) but that the fluid is either of *the* strength, or weaker or stronger;—all the information he needs to guide him in his labors.

Instead of the bubble marked "B" I would substitute two, one indicating 1·100, the other 1·148, and the Italian barometer

makers could easily graduate such bubbles. The whole apparatus is enclosed in a japanned tin box 1 inch deep, $1\frac{1}{2}$ wide and $2\frac{7}{8}$ths long, which can be carried in the waistcoat pocket, and costs but little.

When either of the foregoing fluids are required for the display of preparations in a public or private collection, they should be *well filtered*, and for this purpose they may be passed a great number of times through fine flannel rammed into the nozzle of a large earthen funnel, or once through a filtering machine, or twice or thrice through good filter paper. If the filtration be properly performed, these fluids are remarkably bright, white, and brilliant, far exceeding in this respect any alcoholic fluids. Rough filtration may be satisfactorily effected by once passing through the thick flannel used for a jelly bag; but if this be not at hand, it is only necessary to allow the fluids to stand quietly in the vessel in which they were made until quite cold, and then carefully pouring off the top, the extraneous matter always found in rock salt will gravitate, especially in the aluminous fluid, which has the property of throwing down any thing which disturbs the transparency of water. Neither of my fluids can be retained in open vessels, glass jars, or even stoppered bottles, for any length of time, without additional protection.

In *open* vessels, the water evaporates, and the salt crystallizes, to the total destruction of the specimens included. Salt, being highly deliquescent, the volume exposed to atmospheric influence (the upper portion) becomes greatly diluted when the atmosphere contains moisture and ascends into the neck of a bottle, even around a well ground stopper, by capillary attraction; it gains the upper surface of the stopper and then descends the sides of the bottle, and will lie as a pool on the shelf on which the bottle rests.

As the weather changes, and becomes dry, the salt crystallizes, and thus forms a conduit for the fluid the next rainy day, by which it can greatly, and readily, extend its outposts; and by this means, in time, it will pass completely out of the bottle or other vessel. Bladder will not confine it, applied to a glass jar on the plan employed for spirit preparations; and the only plan is to cover the jar with a plate of *flat* glass (patent British plate manufactured by Messrs. Chance of Birmingham, is the best) and seal it down with the patent marine glue, applied to the glass, with a hot iron.

The best, neatest, and readiest mode, in my experience is the plan of my invention, namely: first place in the upper vessel of a small copper glue pot some marine glue cut small; in the lower vessel, where the carpenter would put water for the careful dissolution of animal glue, put linseed oil, and then apply heat; the temperature of the boiling oil will dissolve the glue the first, second, and even a third time, with care; after this it becomes altered in its properties, and refractory.

The dissolved glue should be rapidly applied to the rim of the glass jar (which must be quite dry and free from grease,) with a brush, and the only brush that will stand, I make in this way. I take a piece of rattan cane as long as a cedar drawing pencil, and cut off the cortex carefully from one end of it to the length I desire the brush to be, being particular not to let the knife go into the substance of the cane any more than I can help. I macerate the prepared end of the cane for a short time in water, and then, while yet wet, I pound it with a hammer upon some hard substance (iron or stone) constantly turning it with my hand until all the fibres of the cane be liberated, and my brush is then complete. I still use a brush of this kind which I have employed for several years extensively, and none other will stand twice using, the hairs come out with the glue, and are in the way of a good joint. A disc of glass should be cut to fit the top of the jar, made clean, and the part that is to be in contact with the jar also thinly coated with the hot glue. The disc should previously have had a small hole drilled through the centre, (about one-eighth of an inch diameter) for a reason that will presently appear.

The two surfaces of glass being *apparently* coated with marine glue, but *really without contact*, the latter must be insured by means of a hot iron which should be carefully passed over the surface of the glue several times till it and the glass become hot, care being taken to keep the iron constantly in motion, and always on the edge of the jar, or of the disc, as in that case the expansion will be equal, and no danger occur even if the iron be *red hot;* but, it will instantly break if the iron be allowed to linger in one place, or touch any but the outer portion of the disc, or the rim of the jar.

The jar should be thus prepared while *empty, and dry;* and when complete, the fluid may be poured in, to about one-half the height of the jar, together with the preparation to be suspended in it. The strings necessary for this purpose may be brought over the edge of the jar, and pressed into the glue on the surface, if soft enough to admit of it; the preparation may now be regulated to the required height in the jar, and the threads of suspension kept in their place by a wet string passed round them on the outside of the jar, several times. If any fluid chance to be on the surface of the marine glue on the rim of the jar, it should be removed; and when dry, the prepared surface of the disc should be placed on the jar and the two brought together in intimate contact by the hot iron, which, as in the former case, must be constantly passed round on the edge, and the disc simultaneously pressed down, until the process be completed. The extraneous glue on the outer edge may be made smooth and neat, by the hot iron.

By means of a syringe, to which a small pipe is affixed, fill up the jar with the preserving fluid, not quite full, however, as the

great expansion of the fluid (the B especially) in sudden increase of temperature, may cause the breakage of the top glass; then cut a cork to fit the small hole tightly, insert it, pare it off level with the surface, place upon it a piece of solid marine glue made to adhere to the cork by means of the point of the hot iron, and cover it with another disc of glass of about the size of a ten cent piece, and the preparation is finished.

It is a good practice to prepare the portion of thread that is to come outside of the jar, the cork, and even the surfaces of glass to be coated, with a liquid solution of the marine glue, which may be made by dissolving a piece of glue in an excess of white-wood Naphtha.

Should a stopper become fixed in the neck of a bottle by the crystallization of the salt, it may be easily removed by dissolving the salt by water, and gently tapping the cross piece of the stopper at its extreme ends, (*never across its shortest diameter*,) with a door key. If the cross piece come off, make it, and the remainder of the stopper that is in the neck of the bottle *hot* with the iron, apply marine glue, and cement them together,—when cold, renew your operations,—the stopper is stronger now than before, will easily come out, and last longer than one not broken. To keep the fluids in stoppered bottles and to prevent the possibility of the salt crystallizing on the outside of the stopper, the marine glue may be advantageously employed; or a cement, proposed by Prof. Olmsted, of Yale College, and made by melting resin and lard together by the application of heat, and intimately mixing them. The respective quantities of the materials will depend on whether the cement is required to become hard, or not. If the former, the resin must be in excess; if the latter, use more lard. For the purpose that I indicate above, it should be *stiff*, and *ropy;* remaining just soft enough in hot weather, to spread with a palette knife.

As a final remark I would say, that the preservation of animals, either in alcoholic, or my fluids, is greatly facilitated by employing, in the first stages of the process, a large volume of fluid.

Crowding animals together in a limited space, and with only a small quantity of fluid, is a fruitful source of injury and loss of the majority, if not of all the specimens; when, however, the preservation is completely effected, the specimens may be packed very closely together, in a small vessel, and as much fluid of required strength as will occupy the interstices is amply sufficient for transportation, or stores, and will last for years, especially if the fluid be kept in, by running some marine glue round the stopper and neck of the bottle with a hot iron, or by using the resinous cement.

In another paper I propose to treat of the modes of making preparations.

Art. XL.—*Mineralogical Notices.* No. III.

(Concluded from page 222.)

Orangite.—Dr. C. Bergemann of Bonn, (Pogg. Ann., lxxxii, 561,) thus describes the mineral Orangite which contains the metal, Donarium. Color yellowish-red, passing either to brown or yellow; powder or streak light orange. In thin splinters transparent, and in larger pieces translucent. Structure foliated in one direction; cross fracture flat conchoidal. Hardness between fluor spar and apatite, or 4·5; specific gravity 5·397, Bergemann, 5·34, Breithaupt. Small splinters heated in a platinum spoon become dull-brown, and on cooling again of an orange color, and the larger pieces lose their translucency. In a glass tube gives off moisture. Held with the platinum forceps in the flame of a spirit lamp, there is slight decrepitation. B.B. on charcoal infusible, the edges only being slightly glazed and perhaps only from a mixture with foreign matters. Mixed with soda the silica is dissolved, and the rest remains in the glass rendering it opaque. With borax a yellowish pearl, becoming colorless on cooling; with salt of phosphorus in the outer flame, a reddish glass, in the inner, yellowish, and in either case colorless on cooling. With acids easily decomposed yielding with muriatic acid a perfectly clear jelly, of a yellow color, and it is even attacked by dilute acid. Digested for twenty-four hours with a solution of an alkaline carbonate of ordinary concentration, it is strongly acted upon.

This mineral is from Langesundfiord near Brevig in Norway, where it occurs in zircon syenite, with wöhlerite, mosandrite, thorite, zircon, hornblende, black mica. Its composition is given on page 280 of this volume.

Loganite, a new mineral; Mr. T. S. Hunt, (Phil. Mag. [4], ii, 65, July, 1851.)—Loganite occurs at Calumet Island on the Ottawa in white crystalline limestone, mixed with green serpentine, phlogopite, pyrites and rarely crystals of apatite. The form appears to be a prism, with the acute and obtuse lateral edges replaced and also the acute solid angles. Crystals small; edges generally rounded, and faces faintly shining, with the lustre vitreous or vitreo-resinous. Cleavage parallel to the sides and base of the prism distinct, macrodiagonal perfect. Color clove brown to chocolate brown; streak and powder grayish-white. Subtranslucent. Brittle, fracture uneven. Heated in a tube yields water freely with an empyreumatic odor. B.B. loses color, becoming grayish-white, but infusible; with cobalt solution becomes blue. With acids partly dissolved. Composition,

	S̈i	Ä̇l	F̈e	Ṁg	Ḣ & C̈	Ċa
1.	32·84	13·37	2·00	35·12	17·02	0·96=101·31
2.	32·14	13·00	2·28	36·43	16·83	0·93=101·61

In another trial, S̈i 33·17, and C̈ & Ḣ 16·50. Supposing the lime combined with the carbonic acid, it will leave [1], 16·36, [2], 16·12 of water. This affords the Berzelian formula,

$$4\dot{M}g^3\,\ddot{S}i + (\ddot{A}l, \ddot{F}e)^2\,\ddot{S}i + 12\dot{H},$$

corresponding to silica 33·29, alumina 13·31, peroxyd of iron 1·92, magnesia 35·50, water 16·00 = 100·02. In the Gerhardtian notation, the formula according to Mr. Hunt is $Si\,O^3\,(Al\,\beta\frac{4}{5}\,Mg\frac{3}{5}\,H\frac{3}{5})$, the oxygen ratio for the silica and bases being 17·515 : 34·990. It approaches chlorite closely in composition, although not at all foliaceous. The species is named in honor of Mr. Logan, who is at the head of the Geological Commission of Canada.

Matlockite, a new Oxychlorid of Lead; by R. P. Greg, Jr., (Phil. Mag., [4], ii, 120, August, 1851.)—Matlockite occurs at the old mine of Cromford near Matlock, with corneous lead (phosgenite, *Haid.*) Form dimetric; occurs in tables which are generally thin and superimposed on each other, occasionally slightly curved. Cleavage basal, but not perfect. A single crystal in the hands of Mr. W. G. Lettsom is an inch square, an eighth of an inch thick and transparent. The edges and angles are replaced; P : e = 111° 50′; P : a = 119° 34′; e : e = 97° 58′ and 136° 19′; a : a = 104° 6′ and 120° 52′. Color yellowish, sometimes a little greenish. Lustre adamantine and occasionally pearly. G. = 7·21. H. = 2·5–3. Composition according to Dr. R. A. Smith:—

Chlorid of lead 55·177, oxyd of lead 44·300, moisture 0·072 = 99·549, giving the proportions of 1 of chlorid of lead to 1 of oxyd of lead = chlorid of lead 55·46, oxyd of lead 44·53 = 99·99.

The *corneous lead* of the same locality afforded Dr. Smith, Chlorid of lead 51·784, carbonate of lead 48·215 = 99·999.

Pyroxene and Hornblende.—Rammelsberg observes in his 4th supplement, p. 106, that certain augites, as a black augite of Taburg, analyzed by H. Rose, a brown from Pargas, by Nordenskiöld, a black from the basaltic tufa of the Azores, by Hochstetter, have the composition of hornblende; while some hornblendes, as a tremolite from Pennsylvania has the composition of pyroxene. The species have been long known to belong to the same system of crystallization, and to be mutually derivable, and in uralite, as shown by G. Rose, there is an example of a substance with the external form of augite and the cleavage structure of hornblende.

In volume lxxxiii of Poggendorff's Annalen, p. 458, (July, 1851,) Rammelsberg gives the results of analyses of an augite and a hornblende from the basaltic tufa of Härtlingen in Westerwald. He obtained—

	S̈i	Ä̈l	Ḟe	Ṁn	Ċa	Ṁg				
1. Augite,	47·52	8·13	13·02	0·40	18·25	12·76	= 100·08			
Oxygen,	24·69	3·79	2·89	0·09	5·19	5·10				
2. Hornblende,	42·52	11·00	16·59		12·25	13·45	Ṅa 1·71	K̇ 1·92	T̈i 1·01	= 100·45
Oxygen,	22·09	5·14	3·68		3·48	5·38	0·43	0·32		

The second is the mean of three analyses.

The augite gives for the oxygen of the silica, alumina and protoxyds, 24·69 : 3·79 : 13·27; and for the oxygen of the silica and alumina together 28·48. 28·48 : 13·27 = 1 : 2·15. The ratio does not become 1 : 2 except we suppose $2\ddot{A}l$ to replace $1\ddot{S}i$.

The hornblende affords in like manner 22·09 : 5·14 : 13·29, and for the oxygen of the silica and alumina 27·23. 27·23 : 13·29 = 1 : 2·05.

The augite has nearly the ratio usually given for hornblende, 4 : 9; while the hornblende has the augite ratio 1 : 2. So the Taberg black augite affords the hornblende ratio 1 : 2·39 = 4 : 9·5. Rammelsberg hence shows that hornblende does not consist uniformly of $1\dot{R}\ddot{S}i$ with $1\dot{R}^3\ddot{S}i^2$, the usual formula; but that both it and augite may be a pure bisilicate, $\dot{R}^3\ddot{S}i^2$, or may correspond to the general formula, $m\dot{R}\ddot{S}i + n\dot{R}^3\ddot{S}i^2$, in which m and n may be each a unit, or 3 and 2, or other numbers, the addition of m atoms of the trisilicate to n atoms of the bisilicate, producing no change of form. The ratio 4 : 9·33 which is common in hornblende, would give for m, n, the values 3, 2, and afford the formula $3\dot{R}\ddot{S}i + 2\dot{R}^3\ddot{S}i^2$, equivalent to $\dot{R}^9\ddot{S}i^7$. This formula corresponds to the analyses of a tremolite from Fahlun, an actinolite from Taberg, a hornblende from Helsingfors, each containing no alumina; and of the aluminous varieties from Kongsberg, Kimito, La Prese, Lindbo, Vogelsberg, Bohemia, the Uralite, &c.

M. F. Sandberger (on p. 453 of the lxxxiii volume of Poggendorff,) precedes the paper by Rammelsberg by mentioning many cases of the close intermixture of hornblende and augite crystals, and describes cases of twins in which one part of the crystal is augite and the other hornblende. He also describes crystals of augite containing throughout particles of chrysolite, the latter mineral being in parallel combination with the former. In other specimens he finds hornblende and chabasite intimately mingled. This combination of hornblende and augite in a single twin would seem to show that the difference between them is not due to temperature. M. Sandberger urges that the hornblende and augite in the cases adduced cannot be either one or the other a result of pseudomorphism, and that both are properly the same mineral species.

Rutile of Waterbury, Vermont.—Dr. A. A. Hayes in remarking on a specimen of quartz containing acicular rutile from Waterbury, Vermont, before the Boston Society of Natural History, (Proceedings, 1851, 23,) stated that the acicular crystals must have existed occupying a cavity before the quartz was formed. The rutile needles often pass through the regular terminations of the quartz crystals, and roughen the surfaces by their broken ends. The flaws or rents in the mass of the crystal are most frequent about the rutile, indicating that this mineral by its

changes of temperature, as it does not expand at the same rate as quartz, may cause the destruction of crystals of the latter.

Beudantite of Levy.—Mr. H. J. Brooke states (Phil. Mag., [4], ii, 21, July, 1851,) that on showing a crystal of the Beudantite of Levy to M. Descloiseaux, he acknowledged that it differed entirely from the mineral examined by himself and M. Damour as Beudantite, as well as every other specimen under that name which he had seen.

Emerylite on the Diaspore of Katharinenberg.—Mr. Thomas F. Seal of Philadelphia states in a letter to one of the editors of this Journal that he has just received a specimen of the diaspore of Katherinenberg and finds it also quite a good specimen of *emerylite.*

Agalmatolite.—This material is called *Fun Shih* or Powder stone by the Chinese, from its softness. It is often reduced to powder and used in this state in making razor strops. It is found in the Canton province. The reddish colored variety is more common than the green.—*Correspond. of S. W. Williams of Canton.*

Karstenite.—The crystallization of Karstenite has been studied by J. F. L. Hausmann, who points out its close conformity in its angles with heavy spar and celestine, and makes some general remarks on isomorphism or homœomorphism.—*Soc. Sci. Göttingen, March* 15, 1850.

Cinnabar.—A large deposit of cinnabar, yielding 80 p. c. on analysis has been discovered in the island of Corsica.—*J. de. Pharm., March,* 1851.

Gold from California, (Phil. Mag., [4], i, 261.)—Analyses of three samples, after separating the oxyd of iron mixed with it.

I.	Gold	93·53	Silver	6.47 = 100.	A. D. Thomas.
II.	"	93·06	"	6·94 = 100.	F. Walters.
III.	"	96·42	"	3·58 = 100.	A. D. Thomas.

Gold of New Grenada.—The principal deposits of alluvial gold in New Grenada, are those of Sinitabé, Oquendo, Baharona, San Juan, La Vaca and Rio Dulze. The best mines are twenty-five or more in number, of which those of El Zancudo, Titiribe, La Clara, Amalfi and Pedrero are worked. The amount exported and made into coin for the year ending with August 31, 1848, was 5·187 liv.—(Ann. des Mines, [4], xviii, 358.)

On the origin of Ores of zinc, lead, iron and manganese in irregular beds; by M. J. Delanoue.—Ann. des Mines, [4], xviii, 455.

On the Sulphur bed of Szwoszowice, near Cracow; by M. L. Zeuschner.—(Ann. des Mines, [4], xviii, 125.)

On the Nepheline rock of the Löbau mountain ; by Dr. HEIDEFRIEM, (J. f. pr. Chem., l, 500.)—This author finds the mass of the rock to consist of 45·38 p. c. of augite, 32·61 nepheline, 4·00 magnetic iron, 3·91 apatite, 3·42 water, 1·33 titanite, the remaining 9·35 p. c. being in part olivine. The augite, a diopside, consists of

S̈i	Ä̇l	Ċa	Ṁg	Ḟe	Ṁn	
52·54	0·42	25·42	17·54	2·29	*trace*	= 98·21

The nepheline from selected grains, afforded—

S̈i	Ä̇l	F̈e	Ċa	Ṁg	Ṅa	K̇	Ḣ	
43·50	32·33	1·42	3·55	0·11	14·13	5·03	0·32	=100·39

Analyses of the whole stone gave

	S̈i	Ä̇l	F̈e	Ċa	Ḟe	Ṁn	Ṁg	Ṅa	K̇	P̈	Ḣ
I.	41·13	14·33	6·61	12·23	7·20	0·06	5·33	4·38	1·70	1.65	3·42
II.	42·12	14·35	23·12	13·00	—	0·18	6·14	4·11	2·18	1·65	3·42

with chlorid of calcium 0·04, fluorid of calcium 0·27, in each, and in the 2nd, 0·54 of titanic acid.

Variolites of Drac.—Analyses and descriptions are given by M. Gueymard in the Ann. des Mines, [4], xviii, 41.

On the structure and composition of certain rocks of the Alps and Dauphiny; by M. LORY, (Bull. Soc. Geol. de France, vii, [2], 540.)—This paper treats mainly of the hornblendic rocks, diabase and diorite. The diabase of the Chalanches in Allemont (Oisans) consists principally of hornblende of a deep green color, lustrous and largely lamellar; in some parts, the large crystals of hornblende are so filled in with smaller, that there is little room left for feldspar; in others, the feldspar is more abundant, and mixed in with the hornblende like a graphic granite. The hornblende consisted of—

	S̈i	Ä̇l	Ḟe	Ċa	Ṁg	alkalies (diff.)		
Hornblende,	45·3	8·0	25·7	12·3	6·0	1·3	ign. 1·4	=100
Oxygen	21·5	3·7	5·8	3·5	2·2			

The alumina appears to replace silica.

The feldspar afforded on analysis (p. 542)—

	S̈i	Ä̇l	F̈e	Ċa	Ṁg	Ṅa	K̇	Ḣ	
Andesite,	59·4	24·2	0·6	3·7	*trace*	7·0	3·4	1·48	=99·78
Oxygen	30·86	11·31	0·19	1·04		1·80	0·57	1·32	

It is hence andesite having the oxygen ratio for the protoxyds, peroxyds and silica 1 : 3 : 8. The andesite is associated with epidote, which is often abundant. This mineral gave on analysis (p. 543)—

	S̈i	Ä̇l	Ḟe	Ċa
Epidote,	40·6	30·2	11·2	17·7
Oxygen	21·1	14·1	2·5	4·9

Another diabase contains crystallized prehnite in prisms. Its hornblende afforded a different composition from the above, as follows:

	S̈i	Ä̈l	Ḟe	Ṁn	Ċa	Ṁg	Ḣ
Hornblende,	50·9	4·9	21·2	*trace*	11·2	8·7	1·6, alkalies and loss 1·5

The feldspar of the rock is andesite as before, giving:—

	S̈i	Ä̈l	F̈e	Ċa	Ṁg	Ṅa	K̇	Ḣ
Andesite,	59·9	25·1	*trace*	3·7	0·7	7·4	1·2	1·7 = 99·7

A *schistoid diorite* is a common rock in L'Oisans. There is also a *granitoid diorite*, consisting largely of whitish feldspar with disseminated hornblende crystals of a deep black color. The feldspar is *andesite*. This same feldspar is also found in the euphotide of Lavaldens in the department of L'Isère. This rock consists of deep olive green lamellar diallage and the white andesite; the latter afforded on analysis—

S̈i	Ä̈l	F̈e	Ċa	Ṁg	alkalies (diff.)	Ḣ
60·0	23·8	1·1	6·0	1·5	5·3	2·3 = 100

[A doubt existed among some members of the Geological Society with regard to the feldspar in the above analyses being andesite, on the ground that the rocks in which it has been reported to be found may contain some free silica; but this Delesse denies.]

Lava.—Rammelsberg makes the lava of Thjorsá, Iceland, from the analysis by Genth (given in this Journal, vol. vii, 2nd series, p. 114,) to consist of anorthite 55·59, augite 40·46, olivine 4·51. The Thiorsauite of Genth is impure anorthite according to this chemist.

For the lava of Háls, Iceland, which has a grayish black color and sp. gr. 2·919, he gives the composition, lime-oligoclase 63, augite 28, olivine 9. That of Efrahvolshraun, which is uncrystalline, with a black color inclining to gray and sp. gr. 2·776, consists, according to him, of 71·37 of lime oligoclase and 29·66 augite (including olivine and magnetic iron).

The lava of Etna was determined by Abich some years since, to be composed of 54·80 labradorite, 34·16 augite, 7·98 olivine, and 3·06 magnetic iron = 100. That of Stromboli, according to the same author, consists of 48·18 labradorite, 44·91 augite, 6·91 magnetic iron, or 44·30 labradorite, 39·12 augite, and 16·58 olivine. That of Vesuvius, of 60·19 leucite, 20·44 augite, 10·42 olivine, 8·95 magnetic iron = 100.

Rammelsberg also observes that the *Juvenas meteoric stone* has the same composition as the Thjorsá lava of Hecla, it consisting of anorthite and augite in nearly the same proportions.

Red Antique Porphyry.—Delesse has examined this rock with important results, (Bull. Soc. Geol. de France, vii, 524, 1850.) The feldspar is in small oblong macled triclinic crystals, of a whitish or rose color, rarely greenish. G = 2·690. Composition:—

	S̈i	Ä̇l	F̈e	Ṁn	Ċa	Ṁg	Ṅa	K̇	ign.
	58·92	22·49	0·75	0·60	5·53	1·87	6·93	0·93	1·64 = 99·67
Oxygen	30·61	10·51	0·23	0·13	1·55	0·72	1·77	0·16	

This result approaches both the andesite of Alsace and the lime-oligoclase of Forchhammer. The paste of the same rock gave—

S̈i	Ä̇l	F̈e	Ċa	Ṁg	Ṅa	K̇	ign.
62·17	14·71	7·79	3·30	5·00	4·10	2·04	0·58 = 99·69

It is remarkable that the part driven off by heat is much less than with the crystals. Its density is 2·763, which after fusion is reduced to 2·486.

Red Syenite of Egypt.—This syenite, according to Delesse, consists of quartz, orthoclase, oligoclase, mica and often hornblende. Mean density 2·63. The orthoclase is of a reddish color. The feldspar which is commonly referred to oligoclase is usually white, sometimes yellowish or even greenish. The proportions of the ingredients are, orthoclase 43, gray quartz 44, white oligoclase 9, black mica 4.—*Bull. Geol. Soc. de France*, vii, 487.

Mineralogical Notes from the correspondence of Prof. B. Silliman, Jr., dated Italy, May and June, 1851.—Prof. Scacchi published in 1849 a memoir on the Campania, entitled, "Memorie Geologiche sulla Campania," 4to, pp. 131, with 4 plates, Naples. *Misenite*, a new species described in this work by Prof. Scacchi is a sulphate of potash, having the composition $2SO^3\,KO, HO$.

The *Scacchite* is a silicate of lime and alumina containing fluorine, and occurs in square prisms highly modified.

Leucite occurs at Vesuvius in the older ejected blocks as well as the most recent lavas, and it is observed in some instances undergoing a change to Ryacolite, while still retaining the external form of leucite, and sometimes cavities of ryacolite crystals are formed in the leucite.

Zircon occurs at Vesuvius in beautiful white and blue octahedrons in the old ryacolite gangue. *Fluor spar* occurs in octahedrons with hornblende in the older lavas.

Forsterite is identical with anorthite.

Davyne is regarded by Prof. Scacchi as a variety of *Nepheline.* The 6-sided prisms are striated longitudinally, and are modified by a plane on the terminal edges, and another on the lateral; it occurs in a compact pyroxenic gangue, while the Nepheline occurs in a gangue of ryacolite.

Arragonite is formed in an old mine at Monte Vasa from day to day, at a temperature below that of boiling water.

Buratite comes from Campiglia in the Maremma Pisena in Tuscany, and not from Volterra.

Tourmalines of Elba.—In the Grand Duke's collection at Florence there is a specimen 11 inches square, with four erect

green tourmalines and one prostrate, 2, 4, and $2\frac{1}{2}$ inches long, and $\frac{3}{4}$ to 1 inch thick. They are associated with orthoclase and crystallized quartz. The pink tourmalines of Elba have always the basal plane 0R, while the green prisms are terminated with rhombohedral planes.

Analcime?—A singular Analcime-like mineral occurs at Monte Catini, in which the soda replaces magnesia, according to Prof. Meneghini of Florence, who obtained for its composition—

$\ddot{S}i$	$\ddot{A}l$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
59·347	22·083	10·250	0·450	0·015	7·560

[This result gives the oxygen ratio for the protoxyds, peroxyds, silica and water $1 : 2 : 6 : 1\frac{1}{3}$.]

Blowpipe test for Sulphur.—The test for sulphur by means of the nitro-prussid of soda, is suggested by Prof. J. W. Bailey, in volume xi, of this Journal, p. 351. The following are more minute directions for the use of this elegant test.

Heat by blowpipe any sulphuret or sulphate (or any thing containing sulphur) upon charcoal with carbonate of soda, put the fused mass into a watch glass with a drop of water, and add a particle not larger than a pin's head of the nitro-prussid of soda; there will be a magnificent purple at once. If this test for sulphur is tried upon parings of nails, hair, albumen, &c., I would advise that the carbonate of soda be mixed with a little starch, which appears to prevent the loss of any of the sulphur by oxydation. If you wind up a piece of hair four inches long by coiling it around one point of a platinum support, then moisten it and dip it into the mixture of carbonate of soda with starch, and then heat by blowpipe, the fused mass will give with the nitro-prussid an unmistakable action indicative of sulphur. This experiment any one can repeat. By careful management I obtained perfectly satisfactory results from a piece of hair less than an inch long.

Hausmann on the Artificial Formation of Minerals, (Beit. z. Met. Krystallkunde, Göttingen, 1850.)—The species which Hausmann enumerates as forming about furnaces from furnace action are the following; silver, lead, copper, iron, bismuth, galena, blende, oxyd of zinc, red copper, specular iron, magnetic iron, chrysolite, an iron-magnesia, pyroxene containing alumina, $(\dot{F}e, \dot{M}g)^3\ (\ddot{S}i, \ddot{A}l)^2$, chytophyllite, humboldtilite, orthoclase, lead vitriol, arsenate of copper? and arsenate of nickel.

Brown, yellow, green and black blende have been formed in the furnaces of the Lauten valley in the Hartz, in regular octahedrons with modified edges and in dodecahedrons. Blende also occurs lamellar or even radiated.

Galena also is often formed by sublimation in the chimneys of furnaces, and the crystals are uniformly cubic with the usual

cleavage. Octahedral and cubic crystals of *magnetic iron* sometimes incrust cavities in the stone or brick work of the furnaces.

The chytophyllite, (p. 35,) has the formula (Ḟe, Ċa) (S̈i, Ä̇l), and consists of

S̈i	Ä̇l	Ḟe	Ċa
54·897	5·078	20·794	20·346=101·115

It is foliated columnar, not unlike some kyanite, with the color pearl gray, having a shade of lavender blue. Luster of folia between vitreous and pearly; translucent, when thin. Specific gravity at 15° R. 2·940. H.=5·5. Breaks with difficulty being tough. B.B. fuses easily with intumescence to a greenish-black glass, not magnetic.

New American localities of Minerals; by F. B. Hough, A.M., M.D. (Communicated for this Journal.)—*Sulphate of Barytes*, in a highly crystallized form, associated with an extremely unctuous variety of specular iron ore and serpentine, on the farm of James Morse, in Gouverneur. Specimens from this place are full of angular cavities from the intersection of tabular crystals.

Chondrodite occurs abundantly disseminated through white limestone, about three-fourths of a mile west of Somerville, in the town of Rossie. This is the only place where it has been observed *in quantity* in Northern New York. It is associated as usual with

Spinel, in perfect octahedrons with but few modifications. The latter mineral is of a pale rose color, and when in small crystals, is nearly transparent. They occur from an inch to less than a line in diameter and are frequently grouped together in great numbers. The large crystals are quite rare, but the smaller ones are common.

Apatite, in the town of Gouverneur, about two miles north of Somerville. Large crystals occur through the soil and in the subjacent limerock. Most of those hitherto procured have been from the partially decomposed rock.

One crystal had a length of one foot and a diameter of two inches. The form of the crystals is very perfect, except the terminal planes which are covered with pits and irregular indentations. The quality is very poor, but doubtless translucent and highly colored specimens might be obtained from the rock.

Sphene, in large brown crystals, has been obtained from the town of Macomb, in the vicinity of Pleasant Lake. The quality is very inferior, and crystalline form imperfect.

Galena and *Zinc Blende*, have been observed in considerable quantities in the town of Macomb, about half a mile from the Wilson Lead Mine. It is on the land of James Averil, and is owned by that gentleman and Messrs. Wilson and Smith. These ores occur disseminated through a friable limestone rock, to the width of several feet, and promise a profitable yield of these met-

als. *Carbonate of lead* in a white powder is the only associated mineral of interest.

Crystallized Specular Iron ore, associated with elegant crystallizations of quartz, have been discovered on the farm of J. Smith, in Gouverneur, St. Lawrence county.

Phlogopite, in large plates and spheroidal concretions, and containing minute crystals of *garnet*, has been obtained in considerable quantities in a working for iron ore in Gouverneur, near the mill of R. K. Smith. The mica crumbles soon when exposed to the weather. *Crystallized specular iron ore* is associated with it.

Arragonite, in snow-white concretions on surfaces of iron ore, at a new working at the Parish iron mine in Rossie, St. Lawrence county.

Tremolite, in great variety and abundance on the farm of F. Arnold, in the town of Diana, Lewis Co., associated with white limestone.

Notices of Localities in New England; by Mr. Jas. J. H. Gregory, of Marblehead, Mass. (Communicated to one of the Editors.)

Sullivan, N. H.—Tourmalines! In quartz, of a deep brilliant black, with terminal planes; found about a mile south of the center of the town.—Beryls are *said to be* found in the same locality.

Surry, N. H.—Amethyst; in the great railroad cut imbedded in calcareous spar, but now rare. I was informed that they had been found in other parts of the town. Calc spar, variety called *nail-head spar*, in slabs lining seams in the granite.

Grafton, N. H.—Garnets; from a quarter of an inch to an inch in diameter; well crystallized, but of a dull color and with faces unpolished: very easily obtained from decomposing slate rock.

Hartford, Vt.—Calcareous spar, in masses in a ledge cut through by the railroad near the Connecticut river.—Iron pyrites, crystallized in cubes, some of which are two, three, and four inches in diameter and have a good polish, considering their size. Found in a ledge about one-fourth of a mile from the calcareous spar.—Kyanite, in numerous crystals large and distinct, but those I have seen are not generally of a rich color; perhaps this may be accounted for from the fact of their being blasted from the surface. Occurs in numerous veins passing through mica slate, near Hartford center.

Bethel, Vt.—Actinolite! In brilliant crystals in talc. Found very abundantly in a dyke passing through a hill.—Steatite, containing crystals of bitter spar.

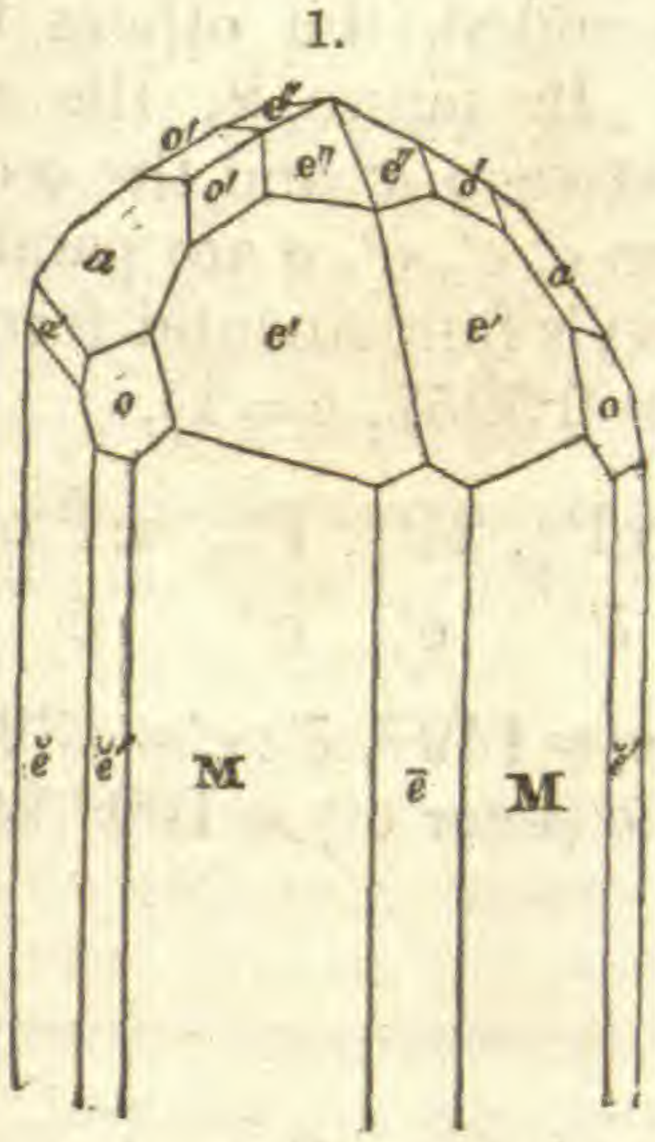
Royalston, Mass.—Mica! at a locality situated about four miles beyond the old one in South Royalston. The mica is of

a brilliant bronze, crystallized on three sides, and affords specimens much superior to those of the old locality.—*Beryls!* The beryls approach nearer to aqua-marines and generally are of a smaller size, and clearer, than those of South Royalston. Those of a sky-blue in the white quartz are very beautiful.—*Feldspar.* In crystals of the same form as those of the old locality, large and scarce. These minerals occur in worn granite on the farm of Mr. Solyman Heyward or Heywood.

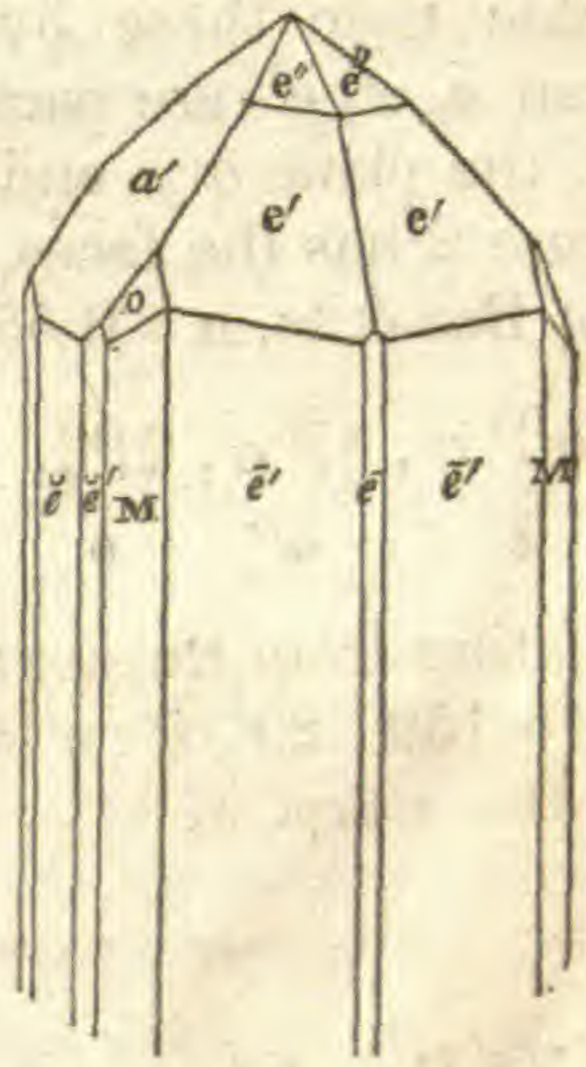
ART. XLI.—*On the Crystallographic Identity of Eumanite and Brookite;* by J. D. DANA.

A FEW days since, I received for examination from Mr. J. E. Teschemacher of Boston, two minute crystals of the Eumanite of Prof. Shepard. They had been long in his cabinet, and were procured from a specimen of the Chesterfield vein, the same locality that afforded the Eumanite. They have the same dark brown color, with a deep brownish red translucence, "like almandine garnet." The hardness, as Mr. Teschemacher observed, is about 6, or not above 6, scale of Mohs. A comparison of the figures here given will make obvious the identity of the two; figure 1 represents Prof. Shepard's crystal, figure 2, Mr. Teschemacher's.

1.



2.



The latter is only $\frac{1}{30}$th of an inch in length, and as no reflection of distinct images could be observed on account of its minuteness, I was compelled to adopt the less accurate mode of measurement by a reflection of the sun's rays. The result has proved that Eumanite and Brookite are very closely similar, not only in physical characters, but also in crystallization. The two crystals strikingly differ though so nearly alike in form. The lateral planes which are the largest in figure 1, are quite small in

figure 2, and, the large lateral planes of figure 2 are wanting in figure 1. The angles obtained are as follows, together with those given by Shepard and the corresponding angles of Brookite.

	Eumanite. Shepard.	Eumanite. Dana.	Brookite.
$\breve{e}' : \breve{e}'$		100°–101° (fr. $\breve{e}:\breve{e}$)	100°–100° 35′
M : M	123°	123° 08′ (fr. $\breve{e}$: M)	
"		121°–124° (observed)	
$\bar{e}' : \bar{e}'$		139°–142°	
$a' : a'$ (over base)		102° 11′ (fr. $a' : a'$, over summit)	102° 24′, Levy.
$a' : a'$ (over summit)		77° 49′	
M : $\breve{e}$	118°–118° 30′	118° 26′	
$\breve{e}$: $\bar{e}'$		108°–110°	
$\breve{e}$: $\breve{e}'$		130°–130° 30′	130°–130′ 18
M : e′	136° 0′		
e′ : e′	151° 30′	150° 12′	
e′ : e″	159° 30′	159° 28′ (fr. $\bar{e}'$: e′ and e″)	
$\bar{e}'$: e′		140° 02′	
$\bar{e}'$: e″		119° 30′	
$\breve{e}$: a	127° 40′		
$\breve{e}$: a'		141° 5 (*calc.* fr. $a' : a'$)	
a : e′	127° 30′		
a : o	144° 20′		
$\breve{e}$: o	128° 20′		
e′ : o	156° 30′		

The first two of the angles of Brookite mentioned are angles of a vertical and horizontal prism, and consequently they determine the dimensions of the crystal and prove the identity as perfectly as if all the other angles were added, the others being deducible from these by calculation. In figure 2, the edges between $\breve{e}$, e′, e″ are parallel; those between a' and the o either side of the plane a'; and those between o, e′, e′, o are parallel.

Figure 2 has the faces, (adopting Levy's fundamental form and axes of Brookite, $a = 0{\cdot}5558$, b ($\breve{e}$ to $\breve{e}$) $= 0{\cdot}5957$, $c = 1$),

$$\infty\bar{P}\infty\,,\ \tfrac{4}{3}\bar{P}\infty\,,\ 2\breve{P}\tfrac{3}{2},\ \infty\breve{P}2,\ \infty\breve{P}3,\ \infty P\tfrac{9}{2},\ 2P\tfrac{9}{2},\ P\tfrac{9}{2},\ \infty\breve{P}\infty$$
$$\breve{e}\qquad a'\qquad o\qquad \breve{e}'\qquad \mathrm{M}\qquad \bar{e}'\qquad \mathrm{e}'\qquad \mathrm{e}''\qquad \bar{\mathrm{e}}$$

Calculating from these axes gives, e′ : e′ = 149°, $\bar{e}'$: e′ = 139° 53′, e″ : e″ = 159° 20′, $\bar{e}'$: e″ = 120° 41′, o : o (over e′) = 100° 26.′

New Haven, Sept. 23.

ART. XLII.—*Observations on the Pendulum Experiment;* by

REV. C. S. LYMAN.

THE fact that the plane of vibration of a free pendulum has a movement in azimuth around the vertical, had been observed by many experimenters, before it was brought so prominently into notice by M. Foucault in connection with the rotation of the earth. This movement is distinctly described, and illustrated by a figure, in some manuscript observations on the motion of a

pendulum by the Florentine Academicians, but without any intimation of its cause. That such a motion was to be expected, was also suggested by the Marquis de Poli, (Phil. Trans., 1742,) and by Poisson in 1837, but without giving the subject any further attention, or attempting to test it by experiment.

The observed independence of the plane of oscillation of a vibrating steel rod inserted in the revolving arbor of a lathe, appears first to have suggested to M. Foucault the idea that the plane of vibration of a free pendulum would, in like manner, be independent of the rotation of the earth.

The experiment was first tried by him with a pendulum six and a half feet in length suspended from the vaulted roof of a cellar, and with entire success. It was subsequently repeated, in connection with M. Arago, at the Paris Observatory, with a pendulum thirty-six feet long. This was in February, 1851. Since that time the experiment has excited general interest, and numerous repetitions of it have been made both in Europe and America.

We propose in the present article to give a general summary of information on this subject, derived partly from published accounts, and partly from our own experiments.

1. *The method of suspension.*—Foucault used a fine steel wire inserted at the top into a hole just large enough to receive it, made in a steel plate which was fastened to the ceiling. The same method of suspension was employed by Mr. Bunt at Bristol, England, by Profs. Carswell and Norton at Providence, R. I., in the experiments at the Capitol in Washington, and in those at New Haven. Indeed this appears to have been the mode generally adopted by those who have repeated the experiments. At the U. S. Armory in Springfield the suspension at top was by means of a pointed steel pivot resting on a hard surface, and the same method has been elsewhere tried, both in this country and in Europe, with a view, probably, in most cases, to avoid friction, but in others, perhaps, to obviate the supposed prejudicial effect of the rotation of the point of support—a matter which, as we shall see, is of no consequence whatever. Others have devised more complicated modes of suspension, such as gimbals with knife edge pivots, the principle being that on which chronometers, marine compasses and barometers are suspended.

But besides the danger of errors arising from imperfect workmanship in these complicated devices, it is not certain that they present any advantages over the first named method, viz., the insertion of the upper end of the wire by soldering, or otherwise, in a firm metallic support. If the wire is equally flexible in all directions, this method is as good as can be desired, and whether the wire is thus flexible or not, may be ascertained experimentally in the manner suggested by Prof. Bache at Washington; namely, by placing the portion of the wire at which the flexure

is to take place in a horizontal position, and after attaching a small weight to the extremity of it, observing whether the weight bends it down always to the same extent while the wire is turned around on its axis. If any error in the movement of the plane of vibration of the pendulum is due to a different flexibility of the wire in different directions, the effects of it may be eliminated by so constructing the support to which the wire is attached that it can be shifted in azimuth during the experiments.*

2. *Length of Pendulum wire and weight of ball.*—The greatest length hitherto employed was that of 220 feet, at the Pantheon at Paris. The pendulum at Bunker Hill Monument was 210 feet long. That used at Providence was 97 feet, that at New Haven 71 feet, while in Great Britain and on the continent, few of the pendulums used were over 50 or 60 feet in length. In many cases they have been less than ten feet; and even with these the change in the direction of the plane of oscillation is clearly shown. The weight of the ball employed has been very various, ranging from two to eighty or ninety pounds; and it has usually been made of lead, which, on account of its great specific gravity, is better adapted to this purpose than any other of the ordinary metals.

Iron has been suspected by some to be an unsuitable material on account of its magnetic qualities. Mr. Bunt at Bristol, from some experiments with an iron weight, in which he was troubled with very anomalous results, inferred that it was owing to the influence of magnetic currents. But it is difficult to conceive how the fluctuating irregularities which he observed, could be produced by such a cause; and, besides, M. Bravais, in his experiments on the revolutions of a conical pendulum, employing a weight composed of mercury enclosed in some experiments in a copper shell and in others in one of iron, could detect no difference in the results, and concluded from his very delicate experiments, that the iron exerted no sensible influence whatever.

It is obvious that the longer the wire and the heavier the ball of a pendulum, the greater will be the probability of accurate results. For the resistance of the air being proportional to the square of the velocity of a body moving in it, this resistance when the mass of the body is great and its motion slow, will have comparatively but little effect on the direction of the vibrations. This is the main reason why short pendulums do not succeed as well as long ones.

3. *Length of the arc of vibration.*—It seems to have been an object with most of the European experimenters to give the

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* Some have completed the suspension at top by means of softened catgut or silk cord, as at York, England, by Mr. Phillips. But the great ellipticity of the path of his pendulum and the irregularities in the results do not strongly recommend such a method.

pendulum a very wide swing, for the purpose doubtless of having the motion of the plane of vibration, measured on the graduated periphery of the circular table, as obvious as possible. From 7 to 20 feet appears to have been the common measure of the arc of oscillation with pendulums of from 50 to 200 feet in length. For the purpose of exhibition to popular audiences this scale of vibration is doubtless desirable, and the slow measured sweep of the ball of a long pendulum is a very beautiful sight. But for the purpose of philosophical observation a smaller arc is much better. Not only is the resistance of the air proportionately less, but the tendency to an elliptic motion is greatly diminished, and the ease of marking the apparent motion of the plane much increased. A total arc of vibration of 2° or 3° is preferable to one of 8° or 10°. The former corresponds to an arc of from two to three feet in a 60 foot pendulum, instead of 8 or 10 feet, which is a length given it by many experimenters.

4. *Sources of error.*—These are so numerous and obvious, yet difficult to avoid, that the wonder is, not that the experiments exhibit some discrepancy in the results, but that they show so little. Poinsot reasoned that the rotary motion of the earth must tend to affect the plane of a pendulum's vibrations, but concluded that the effect would be too small to become sensible.

The effect of a different degree of flexibility in the suspending wire in one direction from that in another, will be to vary the apparent motion of the plane of oscillation, according to the position of that plane in respect to the direction of maximum or minimum flexibility of the wire. If the wire has not been well straightened, but retains a tendency to coil, this also must necessarily exert an influence on the position of a plane which depends for its persistency solely on the inertia of the vibrating body.

The pendulum weight must be a true solid of revolution, with its centers both of figure and gravity strictly in the line of suspension. If it be not so, the unequal action of the air on different parts of its figure will be sure to vitiate the results. Whether this coincidence of centers actually exists can only be determined by careful trials; for the figure may be perfect and all look well to the eye, while yet one part of the casting may, for some reason, be considerably more dense than another, or contain concealed air-bubbles, which will have the same effect on the results.

Undoubtedly the worst difficulty to be encountered is the effect of currents of air. Even if the air were perfectly motionless in respect to the apartment, yet moving with the apartment along with the earth in its rotation, it must tend to carry the ball along with it around the vertical, and thus, in some degree, diminish the amount of motion which the plane of vibration would otherwise have. But besides this effect, the air must produce other and still greater disturbances, in consequence of the cur-

rents into which it is constantly liable to be thrown. Few apartments are closed perfectly tight; or if there be no currents from this source, the motion of the observer in the room, his respiration or the heat of his body, will constantly tend to disturb the equilibrium of the air; and how great an effect on the delicate movements of the pendulum the slightest current will have, may be learned by breathing ever so gently towards such a pendulum when in motion. A single breath will throw it into an elliptic path and sensibly change its plane of oscillation.

One great source of the elliptic motion so constantly observed in these experiments undoubtedly is the almost insensible lateral oscillation which the pendulum is apt to have at the moment of being let off, notwithstanding the utmost care that may be taken to extinguish it. Perhaps as good a way as any to secure perfect quiescence at this moment, is to bring some smooth surface, like that of an ivory scale, into contact with the point of the pendulum index, while the other end of the scale resting as the short arm of a lever, on some solid support for a fulcrum, is gently pressed by the finger. In this way the contact can be delicately renewed and broken till the slight friction on the point of the pendulum gradually brings it to rest.

The common method of starting the pendulum by suddenly letting loose the single thread attached to the loop which retains it, is perhaps the best that can be employed.

5. *Phenomena observed.*—When a pendulum, freely suspended as before described, is put in vibration, the plane of oscillation is seen gradually to change its position in reference to the points of the compass, or to have a horizontal movement of rotation around the vertical from left to right, or with the motion of the hands of a watch.

The *rate* of this angular motion has been the point to which most persons who have repeated the experiment, have directed their attention. It has been observed to be different in different places, and to correspond approximately to the amount assigned by mathematical investigation, namely, the angular motion of the earth on its axis multiplied by the sine of the latitude. A further examination of this expression for the rate of motion will be given further on.

The rate of motion per hour, however, as given by experiment, is by no means a constant quantity, even at the same place and with the same pendulum, varying often in different trials a degree, and sometimes two or three degrees, from the mean, or from the theoretical amount.

Mr. Thomas G. Bunt, of Bristol, describes in several papers published in the Philosophical Magazine, the results of numerous experiments made at Bristol, with a pendulum 53 feet in length and weighing 53½ pounds; to which he gave, in his earlier ex-

periments, an arc of vibration of about seven feet, but in his later ones, of one or two feet only. Mr. B. appears to have taken much pains to note the amount of elliptic motion which the pendulum acquires, and applied to the observed angular motion of the plane of vibration certain corresponding corrections, to obtain his tabulated results.

The following table contains the observed rate of motion, and other particulars of the experiments, at the several places named. We regret that the results of the experiments of Prof. Horsford, at the Bunker Hill Monument, are not within our reach.

Place.	Length of pendulum.	Initial arc of vibration.	Observed motion per hour.	Calculated motion per hour.	Latitude, North.	Whole time observed.	
			°	°	° ′	hours	
Bristol, Eng., . .	53 ft.	8 ft.	12·097	11·763	51 27	26½	
(T. G. Bunt,) . .	"	"	11·945	"	"	. .	Mean of preceding with additional experiments.
	"	4 ft.	11·677	"	"	37	Corrected for ellipticity
	"						
	"	14 in.	11·651	"	"	4	
	"	short	11·750	"	"	326½	41 trials uncorrected for ellipticity.
Dublin, . . .	35 ft.	4 ft.	11·900	12·073	53 23	. .	(Galbraith and Haughton.)
York . . .	52	14 ft.	13·12	12·163	53 58	. .	4 trials.
(J. Phillips,) . .	5¾	18 in.	11·94	"	"	. .	4 " weight 1 1/12 lbs.
Geneva, Sw., . .	66½	11 ft.	11·848	10·856	46 12	9	4 " E. and W.
(Dufour & Wartmann)	"	"	10·522	"	"	9	4 " N. and S.
New York City, .	9 ft.	—	9·733	9·815	40 44	—	(Prof. Loomis.)
Providence, R. I., .	97	5 ft.	9·955	10·030	41 49½	—	16 trials, (Profs. Carswell and Norton.)
New Haven, Ct., .	71	3 ft.	9·970	9·928	41 18½	18	16 trials.

The calculated motion per hour in the fifth column, is the actual angular motion of the earth, considered as around the vertical, in one hour of *mean solar time*, and of course is somewhat greater than the product of 15° into the sine of the latitude, which gives the motion in one hour of *sidereal* time.

From this table it will be seen that the observed rate of motion of the plane of vibration per hour, as nearly coincides with the product of the hourly motion of the earth on its axis into the sine of the latitude of the place as could reasonably be expected, considering the many obstacles in the way of accurate results. Some of the observations noted in the table appear not to have been very skillfully conducted, particularly those at York, where the ellipticity sometimes amounted to three or four inches for the minor axis, and was not considered measurable unless it exceeded one-fourth of an inch. The discrepancy among the individual observations was accordingly very great.

The experiments at different places have generally seemed to show, that the rate of motion of the pendulum plane is not at

all affected by the direction of the vibrations in respect to the points of the compass.

Messrs. Dufour and Wartmann, however, at Geneva, found the rate to be less in their experiments when the vibrations were in the direction of the meridian than when at right angles to it, as may be seen from the above table. Hence Gen. Dufour infers, that the formula $A' = A \sin. lat.$, (A = angular motion of the earth, and A′ the motion around the vertical, or that of the pendulum plane,) is not rigorously applicable. M. Morren at Rennes comes to a similar conclusion from his own experiments.

But besides the difficulty of conceiving any physical cause for such a difference, the fact that other experimenters have not noticed it, (although their experiments appear to have been both more extensive and conducted with at least equal care,) may lead us to hesitate about adopting such a conclusion, especially when the results of rigid mathematical investigations of the problem reveal nothing of the kind, but give as an exact expression of the the motion of the pendulum plane the simple formula just referred to. The disturbing causes connected with such experiments are too numerous, and too difficult to be avoided, to allow of any such broad inference being drawn, except as the result of long continued observations, made with reference to every variety of circumstances.

It has also been noticed by some observers, that the rate of motion of the pendulum plane in a single trial, is *not uniform*, but varies in the course of the experiment; generally becoming more rapid as the arc of vibration diminishes. In the experiments at New Haven this acceleration of rate was noticed in a majority of the experiments, though it was much more perceptible in some cases than in others.

Five experiments, in which the pendulum was permitted to vibrate till its plane had passed over 10° on the horizontal circle, gave the times of passing over the first five and last five degrees of the arc, as follows; the pendulum being 71 feet in length, and weighing 12 pounds.

	Time of first 5°.	Time of second 5°.	Length of arc of oscillation at 0°.	Length of arc of oscillation at 5°.	Length of arc of oscillation at 10°
	m. s.	m. s.	inches.	inches.	inches.
1	29 20	28 0	44	26	18·5
2	30 50	30 0	40·5	25	17·5
3	31 5	30 25	40·6	25·2	17·5
4	31 30	31 30	46	27·4	18·6
5	31 50	31 10	44		
Mean.	30 55	30 13			

This varying rate of motion appeared to have no connection, in the experiments at New Haven, with the elliptic motion which the pendulum acquires; for it was often most marked when the

motion of the apses of the ellipse was least, and sometimes even took place directly in opposition to the effects of that motion.

In any series of experiments at the same place and with the same pendulum, there is observed, as was remarked before, considerable *difference* in the rate of motion of the pendulum plane in different trials. Mr. Bunt's results for the hourly rate of motion sometimes differ nearly 2° from each other—though his experiments appear to have been very carefully conducted.

The experiments of Mr. Phillips at York, present still greater discrepancies. At New Haven the rate of motion per hour in different trials, always fell within half a degree of the mean, as will be seen from the following table, which presents more in detail the observations of which some general results were given in a previous paper.

	Time.	Part of azimuthal circle passed over.	Length of arc of vibration at beginning.	Length of arc at end.	Minor axis of ellipse.	Direction of motion in ellipse	Motion of plane of vibration per hour.	Motion of apses of the ellipse per hour.	Motion of plane corrected for ellipticity.
	min.	° °	inches.	inches.	in.		° dec.	°	
1.	41·5	0–7	48·0	23·0	0·02	R	10·12	−0·01	10·11
2.	117·0	0–20	55·0	11·6	·01	R	10·26	− ·01	10·25
3.	36·3	0–6	50·8	27·2	·06	R	9·92	− ·02	9·90
4.	184·2	0–30¾	36·6	6·0	·10	R	10·00	− ·03	9·97
5.	60·8	0–10	40·4	17·4	·20	L	9·87	+ ·06	9·93
6.	61·5	0–10	40·6	17·4	·10	L	9·75	+ ·03	9·78
7.	63·0	10–20	46·0	18·6	·30	L	9·52	+ ·08	9·60
8.	172·8	90–120	44·0	7·2	·16	R	10·41	− ·04	10·37
9.	29·0	90–95	43·4	26·8	·12	R	10·34	− ·04	10·30
10.	61·5	130–140	44·8	18·6	·04	R	9·75	− ·01	9·74
11.	29·5	40–45	48·6	29·8	·10	L	10·17	+ ·04	10·21
12.	95·2	170–185	39·0	12·2	·08	L	9·46	+ ·02	9·48
13.	17·3	130–133	. .	34·4	·08	R	10·28	− ·03	10·25
14.	23 7	41–45	. .	30·0	·00	. .	10·13	·00	10·13
15.	36·3	89–95	46·0	26·0	·06	R	9·92	− ·02	9·92
16.	49·7	0–8	43·0	20·6	·06	L	9·66	+ ·02	9·68
							9·97		9·97

The zero of the horizontal circle was nearly in the meridian. The mean rate of motion, it will be observed, a little exceeds that given by the rule of the sine of the latitude, which is 9°·928, or 9° 55′ 43″ per hour of mean solar time. The number of observations made was not sufficiently great to eliminate entirely the effects of errors of observation, or give anything more than an approximate mean result.

Ellipticity.—The tendency of the pendulum to move in a narrow ellipse, instead of a straight line, has been remarked by all observers; and the degree of ellipticity has, it is believed, been uniformly observed to increase during the progress of the experiment, at least until the arc of vibration had become very short. The ellipticity may be considered of two kinds, the *necessary*, and the *accidental*.

The slight ellipticity which must necessarily be given to the motion of the pendulum by the rotation of the earth itself, has

been perhaps sufficiently illustrated in an article on page 251 of this volume. Such an ellipticity may be produced in an exaggerated degree, by suspending a pendulum from an arch over a whirling-table, so that it may hang when at rest directly in the axis of motion. If the pendulum ball be drawn aside to the periphery of the table, and detained there by a catch, while the table is made to revolve, on being let loose instead of falling in a straight line through the point of rest, or center, it will describe an elliptic orbit, whose minor axis will be proportioned to the tangential velocity of the ball at the moment it is disengaged. If that velocity be sufficient to carry it a quarter round the periphery of the table in the time it would move by the force of gravity to the center, or make half a vibration, the centrifugal and centripetal forces will balance each other, and the pendulum when let loose, move in a circle, with the same rate of motion as that of the circumference of the revolving table.

In the ordinary pendulum experiments, this ellipticity, owing to the slowness of the tangential motion given to the ball by the rotation of the earth, must be very slight; so slight, indeed, as to be nearly or quite insensible to direct observation, being lost amid the accidental sources of elliptic motion, unless the experiment be conducted on an extensive scale. The longer the pendulum and the larger the arc of vibration, the greater will be the minor axis of the ellipse.

The following formula, deduced by Prof. Stanley of Yale College, from a consideration of the forces by which the pendulum is governed, viz., $B = V\frac{2t}{\pi}$, expresses the length of the semi-minor axis (B) in terms of the tangential velocity (V), and time occupied in a semi-vibration of the pendulum (t). Then, A being the length of the semi-chord of vibration, or radius of the circle in which the ball receives its tangential velocity from the earth's rotation, $V = \sin.\lambda\frac{2\pi A}{86400}$, and consequently, $B = \sin.\lambda\frac{2\pi A}{86400} \times \frac{2t}{\pi} = \sin.\lambda\frac{At}{21600}$, λ being the latitude of the place.

For the latitude of New Haven, (41° 18′ 24,″) with a pendulum making a half vibration in $2^{s}\cdot33$, and having a chord of vibration of 4 feet, this would give for the minor axis of the ellipse, $0^{in}\cdot0034$. In the latitude of Paris, with a pendulum 220 feet long, and vibrating 20 feet, the minor axis of the ellipse would be $0^{in}\cdot0344$, nearly $\frac{1}{29}$th of an inch, a quantity easily appreciable in careful observations.

Whether this ellipticity will tend to develop itself in a series of experiments by causing a preponderance of motion in one direction

rather than the other, is somewhat doubtful. Many of the published observations, especially those with long pendulums, seem to indicate such a result. At Providence the motion in three-fourths of the trials was towards the left. With shorter pendulums the ellipticity in each direction seems to have been about equal—though in Mr. Bunt's long series the preponderance was also towards the left.

But the most marked ellipticity, and the one constantly observed in these experiments, is that which may be considered as accidental, and which varies both in amount and direction in different trials. In the experiments at New Haven, the minor axis of the ellipse rarely exceeded a tenth of an inch. Mr. Bunt in some of his trials, and several others, have found it equally small; while others, owing doubtless to a faulty apparatus, or to aerial currents, or unskillful managemennt, have found it amount sometimes to two, three or more inches.

This motion in an elliptic orbit, from whatever source it may originate, necessarily gives rise to a progressive motion of the apses of the ellipse in the same direction in which the orbital motion takes place.

Mr. Airy the Astronomer Royal, Mr. Galbraith of Dublin, and Mr. Thacker of Cambridge, have investigated the nature of this motion, and have given as the result of their inquiries, essentially the same formula for computing the progressive angular motion of the apses of the ellipse. These formulæ, together with the extended analysis of Messrs. Galbraith and Haughton, are published in the August number of the Philosophical Magazine.

The Astronomer Royal concludes from his investigation that, "If the length of the pendulum be a, the semi-major axis of the ellipse described by the pendulum be b, and the semi-minor axis be c, then the line of the apses of the ellipse will perform a complete revolution in the time of a complete double vibration (i. e. the time of describing the ellipse) multiplied by $\frac{8a^2}{3bc}$."

To reduce this to a convenient form for computing the progressive motion of the apses of the ellipse per hour, let m represent that hourly motion, T the time of a complete revolution of the apses, and t the time in seconds of a double vibration of the pendulum; then, as above, $\mathrm{T}=t\frac{8a^2}{3bc}$. But, ($T$ being in seconds)

$m=\frac{360^\circ}{\mathrm{T}}\times 3600$. Substituting the above value of T,

$$m=\frac{360^\circ\times 3600\times 3bc}{8a^2t}=486000\frac{bc}{a^2t}.$$

If $a=71$ feet$=852$ inches, $t=9{,}333$ seconds, $b=24$ inches, and $c=0{\cdot}2$ inches, (b and c being the arithmetical mean of the

values of these quantities at the beginning and end of the experiment,) then, $m = \frac{486000 \times 24 \times 0{\cdot}2}{(852)^2 \times 9{\cdot}333} = 0^\circ{\cdot}3443 = 0^\circ\ 20'\ 39''{\cdot}5$ per hour.

In this manner were computed the corrections for ellipticity given in the last column but one of the table on page 405. It will be seen from this table that the motion of the apses of the ellipse as given by the formula, accounts for but a small part of the difference between the observed rate of motion of the pendulum plane and that which it would have were there no elliptic motion. It must be remembered, however, that the formula does not take into account the resistance of the air, and other fruitful sources of disturbance. The agreement of the formula with the differences in the rates of motion observed by Mr. Bunt is somewhat closer.

The motion of the apses of the extremely narrow ellipse that has been spoken of as arising from the earth's rotation, must tend slightly to diminish the rate of motion of the pendulum plane, since it takes place in the same direction as the motion of the earth. This effect, however, will be entirely insensible, since, even with a pendulum 220 feet in length and vibrating 20 feet, it amounts to only a little more than 3″ of arc per hour.

6. *Connection of the motion of the pendulum plane with the earth's rotation.*—Many persons, even of education, find it difficult to understand how a vibrating pendulum, whose line of suspension must constantly be directed to new points in space as the earth revolves, can exhibit any thing like permanency in the position of its line of vibration with respect to the rotating motion of the earth. It is true that the path of the pendulum ball, considered as in absolute space, is exceedingly complicated, being compounded of its own oscillating movement, the motion of the earth on its axis, and of the earth itself around the sun. But it is not at all necessary to attend to this complication of motions in the problem before us.

In the first place let it be observed, that the direction of the plane of vibration of a free pendulum is entirely independent of any motion, whether of rotation or of translation, that the point of suspension may have. Hold in the fingers a pendulum made of a simple ball and string, and cause it to vibrate; then twirling the string between the fingers will only cause the ball to rotate on its axis, without affecting at all the direction of the vibrations; and walking forward, whether in a straight line or in a circle, will in like manner, only shift the position of the entire pendulum, which will continue to vibrate towards the same point of the compass as at first.

Again let it be noticed, that the direction of the force of gravity being constant, that is, towards the center of the earth, the

relation of the pendulum to that force must also be constant, and its motion is to be treated, not absolutely or in reference to space, but precisely as if the earth were at rest, the equal motion of both earth and pendulum having no effect on their mutual relations to each other, save in the relative change in the horizontal direction of the line of the pendulums vibrations, in consequence of the fact that that direction is entirely independent of the earth's motion, as we have just illustrated. The direction of the plane of vibration depends for its permanency on the *inertia* of matter, and whatever change may be made in the position of that plane in respect to space, or the heavens, by the earth's rotation, precisely the same change of position takes place in the earth itself, and as we have said, the direction of gravity in respect to both remaining the same, we are only required to consider the relative horizontal change that takes place in the angle made by the plane of vibration with a given line on the earth's surface.

At the pole the problem is extremely simple—the plane of vibration remaining constant, and the earth turning under it at the full rate of its angular velocity of rotation, or 15° per hour.

As we recede from the pole, the problem is, to find the true ratio subsisting between the earth's angular velocity of rotation and the latitude of the place, for at the equator both the latitude and motion of the plane are at zero, and no relative angular motion can be exhibited.

M. Binet, (Comptes Rendus, 1851, Nos. 6, 7), Rev. J. A. Coombe, (Phil. Magazine, No. 7, 1851), and other mathematicians, have investigated the problem on the method of resolving the rotary motion of one point on the earth's surface into two, one about the vertical to that point, and the other about an axis at right angles to it and lying in the direction of the meridian. If the motion took place wholly about the latter, which is parallel to the surface of the table over which the pendulum vibrates, the effect would be precisely the same as at the equator, for there this axis coincides with the earth's axis, and in either case there could be no relative motion of the plane. It is the other part of the resolved motion therefore, that is alone effectual in giving the table a virtual motion of rotation in its own plane about its center. If the motion were wholly around this axis, the case would be the same as at the pole, for there this vertical axis would coincide with the earth's axis, and the angular motion would be at its maximum. From these considerations equations are formed from which the exact angular change of position of a line on the earth's surface, considered as around the vertical, is shown to be proportional to the *sine of the latitude.* M. Binet enters into an analytical investigation, in which the conditions of the motion of the pendulum generally are expressed by certain differential equations, the integration of which conducts him to certain expres-

sions, which, when simplified by the consideration of limiting the vibration to small arcs, gives the azimuthal velocity uniform in the direction from left to right, and in the simple proportion of the sine of the latitude.

Prof. O'Brien of Kings College, London, in an article on Symbolical Mechanics, in the August number of the Philosophical Magazine, investigates the same problem, and concludes, "that the effect produced by the earth's rotation on the pendulum is proportioned in every respect to the sine of the latitude."

Perhaps the simplest and most satisfactory method of illustrating the subject to minds not specially trained to mathematical investigations, is that adopted by Prof. J. D. Dana, in a communication made to the Scientific Association at Albany, and published on page 200 in this volume; viz., by drawing lines parallel to each other along any circle of latitude on an artificial globe in the manner fully described in the article referred to.* These lines, it is true, taken as representing the successive positions and directions of the plane of vibration, are not strictly parallel, nor is it necessary to regard them as such, except when considered as placed at indefinitely small distances apart. The continually changing direction of the *axis of suspension* causes a corresponding change in the absolute position of these lines, and hence, considered as in space, they do not lie in the same plane, and of course are not in all respects parallel. But as precisely the same change takes place in the position of the horizontal plane over which the pendulum vibrates, and in the direction of the force of gravity, causing that direction to remain relatively constant, the relative effect, as has been remarked already, is exactly the same as if no such change of position occurred, or as if the successive positions of the line of vibration were in one continued plane, the line maintaining a constant parallelism to itself. But if these lines are parallel, why is not the last in the series, when we have gone round a circle of latitude, parallel to the first? This is not the case, because the lines, though relatively parallel, are not, for the reasons before mentioned, to be treated as absolutely so. They are to be regarded as lines drawn on the surface of a cone at its base—the cone being that formed by the successive meridional tangents to a given circle of latitude, and having its apex at the point where all these tangents meet the axis of the earth produced. Such lines, if not parallel, strictly speaking, when regarded as on the curved surface of the cone, will become truly so, when that cone, considered as made of paper, is cut open from its center outward and spread out on a flat surface.

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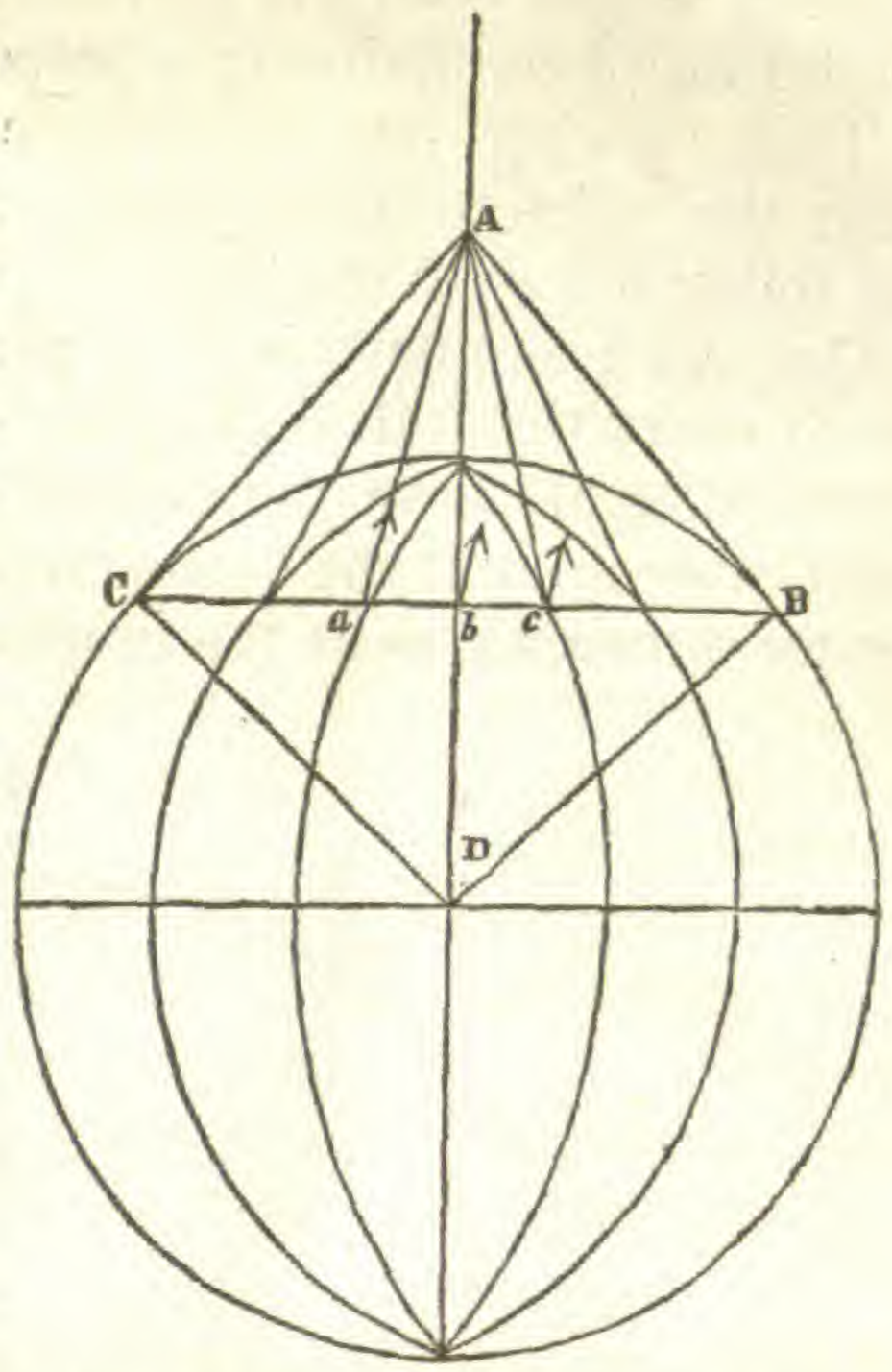
* We have learned since that article was in type, that the same method of illustration has been used by Prof. Horsford.



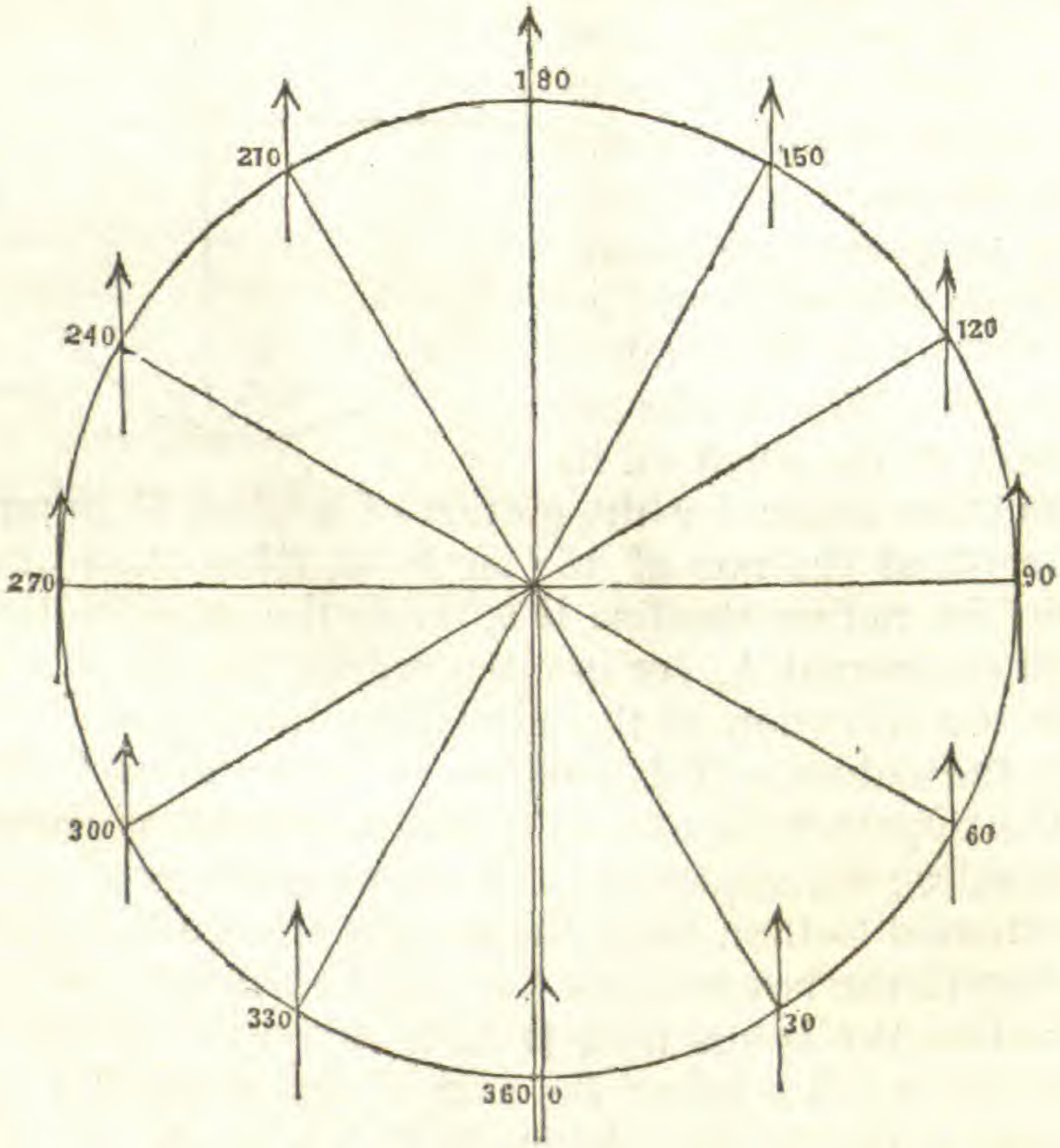
In the accompanying figure the cone formed by the tangents has for the periphery of its base the circle of latitude B C, and the inclination of any two meridians to each other at this parallel of latitude, is represented by the angle formed at the apex of the cone by the corresponding tangents. Let the arrows *a*, *b*, *c*, represent successive positions of the pendulum plane; now, as the earth revolves on its axis, the angle formed by this plane with the meridian, or rather with its tangent, is continually increasing, but evidently increasing not by an amount as great in a given time as the angular motion of the earth on its axis in the same time; for the motion of a place B going round with the earth at the rate of 15° an hour, takes place in a circle having for its radius the line B *b*, while the same motion of B considered as around A, (or in other words, the relative angular change in the direction of the meridian), takes place in a circle of which the radius is B A, a radius as much greater than the other as the hypothenuse of a right angled triangle is greater than one of its sides; consequently, the circumferences of circles being proportioned to their radii, the angular change in a given time must be less in the larger circle than in the smaller, and as much less as the line B *b* is less than B A, or as the sine of an angle is less than radius, (B *b* being the sine of the angle B A *b*, when B A is made radius.) But the angle B A *b*, in the right angled triangle A B D, is the complement of the angle at D, which latter is the complement of the latitude; consequently B A *b*=the latitude; B *b* is the sine of the latitude; and therefore the angular change in the direction of the meridian, and consequently the apparent motion of the pendulum plane, is proportioned to the sine of the latitude.

Now when the pendulum has made one complete revolution around the earth in the circle B C, it has evidently made but a part of a revolution in the circle of which A B is radius; and the total change of inclination of the parallel arrows drawn on a globe to the successive meridians in going once round the globe, must in like manner equal only a corresponding part of 360°. The last line in the series of quasi parallels, therefore, can only be parallel to the first, when the circuit has been made at the

equator, where both the meridians and successive positions of the pendulum plane maintain a perpetual parallelism.

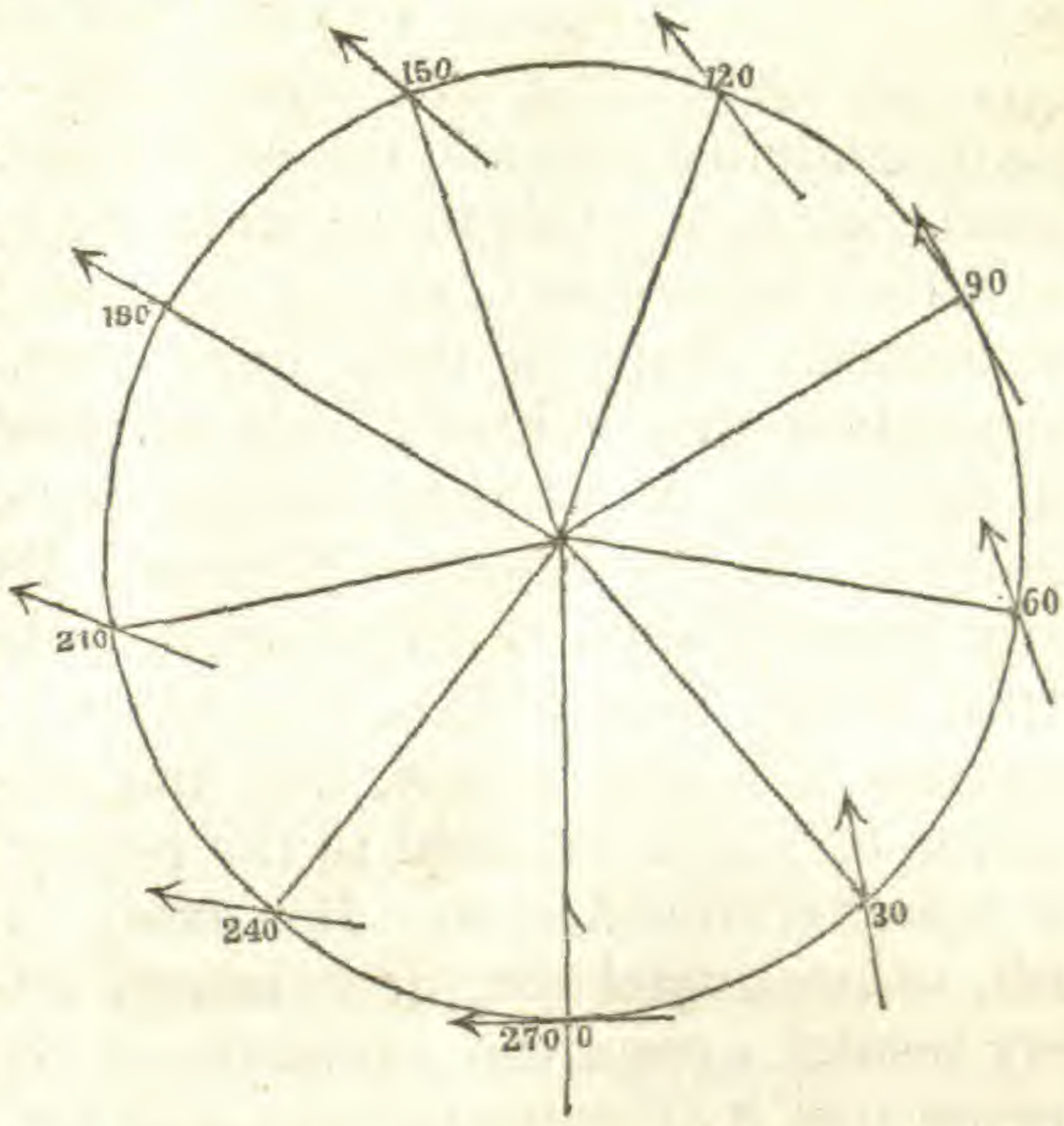
This varying rate of relative angular motion as we proceed from the poles to the equator, may be very simply illustrated by the following easy device.

Cut out a circular piece of paper, and draw radii from its center to every thirtieth degree, as represented in the figure. At the extremities of these radii draw a series of arrows, all parallel to each other around the entire circle. Cut open the paper from the center outwards, as at the double line in the figure.



This paper with its radii may be used to represent the cone formed by the meridional tangents, having the axis of the earth passing up through its apex or center, and its base resting on a parallel of latitude. At the pole, where the tangents touch the surface of the earth, and all lie in the same plane, the sum of all the angles which they form at the center, is equal to 360, as represented by the paper in its original flat condition, its circumference being entire. Let a pendulum be carried around the pole at an indefinitely small distance from it, say a few feet only, and the successive positions of its plane of vibration will be not only relatively parallel to each other, but may be considered as strictly so, as represented by the arrows in the figure. If now one edge of the paper where it is cut open, be lapped over the other, the center will rise and form the apex of a cone; and as one edge of the paper,

with the arrow parallel to it is slid around the surface so as to make the cone gradually more steep, it will be seen that the angle of inclination which the first arrow forms with each successive arrow that it meets, is continually increasing, and is precisely equal to the portion of the original circle that has been covered up by the over-lapping of the sides. Let the edge overlap for example one quarter of the circle, or cut off 90°, the cone will then be as in the accompanying figure.



All but 270° of the entire circle are seen to be concealed; the figures on the margin representing not the angles made by the radii on the present circle, but on the original one. But these 270 original degrees are made to encompass the entire base, or to equal the entire circle of latitude to which the base of the cone corresponds. Instead of 12 radii to the circle, as at first, there are but *nine* of the 12 left; hence each pair of radii, instead of including only 30 degrees of a circle of latitude, includes $30° \times \frac{12}{9} = 40°$, and the angles which the arrows make with the successive radii, viz., 30, 60, 90, &c. degrees are continually falling short of the corresponding angular motion of the earth, viz., 40, 80, 120, &c. degrees, so that when a complete circuit of the earth has been made, or 360°, the arrows have changed their relative direction only 270°, or fall 90 short of making an entire revolution in 24 hours, as will be seen in the figure. $\frac{270}{24}$ gives 11° 15′ for the motion of the plane of vibration per hour in the latitude contemplated. And as this latitude must be that, the entire circle of which is just $\frac{3}{4}$ths of the circle which has the slant height of the cone for radius, as appears from our first figure, it follows that the sine of the latitude must be just $\frac{3}{4}$ths of radius, or the latitude 48° 35′ 25″. When the sides of the paper are lapped so that 180° of the circle are concealed, the first arrow will be found to be parallel to that at the 180th degree, but pointing in an opposite direction, having performed half a revolution during an entire revolution of the earth. The base of the cone, being now just half its original periphery and diameter, corresponds to a latitude the sine of

which is just half of radius, that is, to the latitude of 30°. In this way the base of the cone goes on diminishing as compared with its height until we reach the equator, where the height of it in fact becomes infinite, and the tangents form a cylinder. Of course here the pendulum plane has no relative motion. South of the equator the conditions are reversed, and as we pass towards the south pole, the plane of vibration will be found to revolve in the opposite direction, or from right to left, and with a velocity as in the other hemisphere varying with the sine of the latitude.

7. *Modifications of the experiment.*—Various analogous methods of rendering sensible the earth's rotary motion have been proposed, but none of them, so far as we know, have yet been tested by actual experiment, except that of M. Bravais with a conical pendulum. Many of them have been devised on the mistaken assumption that a heavy body suspended above the earth, will, as the result of its own inertia, be independent of the earth's motion. M. Baudrimont (Comptes Rendus, No. 8, 1851,) not only proposes such an experiment, (a heavy ball suspended by a string as free from *torsion* as possible,) but even imagines, as he explains in a long article, that the principle may be applied, by having an index attached to the heavy body, to the construction of a *perfect time keeper.* But every such device, whether it be a ball, or horizontal rod, or balanced wheel, must fail of showing any results, except the oversight of the contriver, for the simple reason that it contains no provision for divesting the body of the movement which it has in common with the earth's surface, so as to leave it to be governed solely by its own inertia.

The experiment proposed by M. Poinsot (L'Institut, 1851, No. 897,) of a bent spring suspended by its angle and with the two arms tied together by a thread, which thread is to be afterwards burnt and the arms allowed to extend themselves, does obviously contain such a provision, and were it not for the torsion of the suspension wire or thread, might be expected to succeed.

So the device of M. de Tessan, (L'Institut, No. 901, 1851,) viz., a suspended horizontal bar, which while partaking of the rotary motion of the earth, shall by some means be turned end for end, is doubtless correct in principle, since the momentum of each particle of the rod before reversal, would after passing to the opposite side of the vertical, tend to cause the rod to rotate in the opposite direction. But in practice, this momentum would probably be destroyed in passing the vertical, and the experiment prove unsuccessful. A rod suspended by its center of gravity and suddenly let down from a vertical to a horizontal position, would be more likely to succeed—its inertia causing it to maintain when horizontal a constant direction, like the plane of the pendulum. An experiment on this principle was suggested by Lieut. E. B. Hunt at the Albany meeting of the American Scientific Association.

The experiment of M. Bravais, with a conical pendulum, (L'Institut, No. 920, Aug. 20, 1851,) is extremely interesting, and appears to have been entirely successful. He concluded from the nature of the case, that a free pendulum revolving in a circle would perform its gyrations in less time when its motion coincided with the rotary motion of the earth, than when it was contrary to it.

To settle this by experiment, he adopted two distinct methods —that of direct observation, and that of coincidences.

In the first method he observed the time occupied by the same pendulum in making from 900 to 1200 gyrations to the left, and then the duration of the same number of revolutions to the right, the pendulum being 33 feet $5\frac{1}{2}$ inches in length.

The observed times of rotation were as follows.

Right to left.	Left to right.	Diff.
$6^s \cdot 39887$	$6^s \cdot 39825$	·00064
6 ·39925	6 ·39849	·00076
6 ·39815	6 ·39751	·00064
6 ·39959	6 ·39863	·00096
6 ·40106	6 ·40032	·00074
6 ·40116	6 ·40044	·00072
Mean diff. - - - -		·00074
The difference by theory is =		·000716

The second method was even more precise. Two pendulums, one slightly longer than the other, were suspended near each other, in the plane of the meridian. One was set revolving to the right, the other to the left simultaneously, and the passage of the threads across the meridian was observed through a telescope, whose optic axis cut the two threads when at rest. Let n and n' denote the number of oscillations of the respective pendulums between two successive coincidencs, $n'=n+1$, n' being the shorter. At the end of the series the pendulums were set revolving in opposite directions respectively, and the recurrence of the coincidences under the new circumstances, determines the numbers N and $N'=N+1$. Let λ=the latitude, T the length of a sidereal day, t the time of a conical oscillation of the long pendulum, separated from the effect of the earth's rotation, and t' the same for the short pendulum. Then we shall have by theory,

$$\frac{\sin \lambda}{T} = \frac{1}{t+t'}\left\{\frac{1}{n+n'} - \frac{1}{N+N'}\right\}.$$

One trial gave $n=207\cdot86$; $N=217\cdot82$
$n'=208\cdot86$; $N'=218\cdot82$

Another $n=206\cdot31$; $N=215\cdot96$
$n'=207\cdot31$; $N'=216\cdot96$.

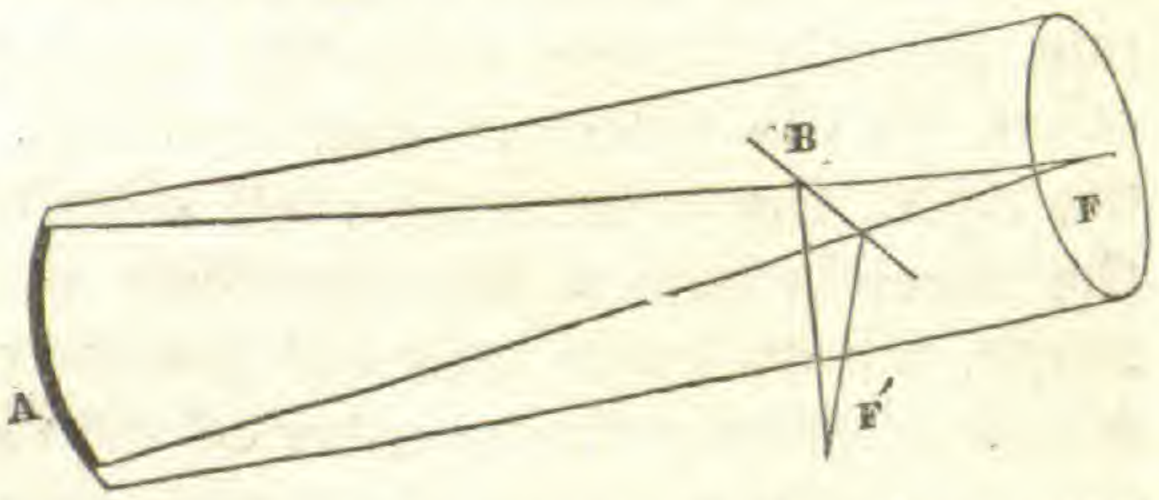
From these numbers the difference in time between a right and left oscillation is found to be, from the first trial, 0ˢ·000725; from the second, 0ˢ·000710.

From these observations M. Bravais concludes that a seconds pendulum, revolving conically, would lose three seconds per day when moving from right to left, and gain the same when moving in the contrary direction. A pendulum 33 feet long would be retarded or accelerated 11ˢ·4 per day. From these observations M. Bravais also computed the length of a simple seconds pendulum, which he made 39ⁱⁿ·1255 instead of 39ⁱⁿ·1291 the number commonly adopted, (993ᵐᵐ·77, instead of 993ᵐᵐ·86.)

Art. XLIII.—*Extracts from the Proceedings of the Twenty-first Meeting of the British Association, held at Ipswich, July 2.**

1. *On preparing Speculums for Telescope;* by the Earl of Rosse.

The Earl of Rosse said that, having observed by the public prints that the President of the Association had, in his inaugural address, done him the honor of alluding with approbation to the attempts which he had lately made, and with considerable success, to produce plane speculums of silver for reflecting telescopes,—he thought it might be acceptable to the Section to receive a brief account of them, and he had therefore come down from London that morning to give them such an account. In order to help their conception of what he had to say, he drew with chalk the annexed sketch. A, the great concave speculum at the bottom of the telescope tube, collecting the rays of light which came from a radiant point placed at a great distance beyond the mouth of the tube to its conjugate focus F. These rays were then intercepted by the small mirror B, and by it reflected to the focus F towards the side of the tube where they were received by the eye-piece of the telescope. Now, speaking roughly, it was found that about one-third of all the light which fell upon the great speculum A, was lost in the act of reflection,—and that of the remainder a considerable portion, but not quite one-third, was lost by the second reflexion at B. Of course, since quantity of light is of the utmost importance to the performance of these tubes, this rendered it a matter of the utmost importance either to get rid altogether of the second reflexion at B, or to obtain some means of producing it subject to less loss of light than that caused by speculum metal; and accordingly, Sir William Herschel, the first who had succeeded in producing reflecting telescopes on a large scale, had, by inclining the great mirror slightly, brought the



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* From the Athenæum of July 12 and 19, Nos. 1237, 1238.

direct image F to the side of the tube into such a position that it could be received directly in the eye-piece. But it was found that correct images could not be produced in this oblique position by speculums of the ordinary form,—and as yet a means of grinding them to a form that would give correct oblique images had not been successfully devised.

He had received numerous and some most ingenious suggestions for placing the observer in such a position as to view the image F directly at the middle of the tube. One difficulty to be got rid of was, that the head and person of the observer would itself abstract much of the light that should be permitted to proceed to the speculum to be there reflected to form the image. Another was, that the temperature of the body of the observer, so much higher as it was than the surrounding air, tended to produce ascending currents, which both produced a wavering motion and an incorrectness of the image quite fatal to the accurate performance of the instrument. These could, perhaps, be guarded against,—and he had received many most curious and some very ingenious plans for disposing even of the entire body of the observer by lying along in a tube properly and well-ventilated with means for conveying away the breath and heated air out of the telescope tube without interfering with the air in the tube itself. But one element in the problem seemed most strangely to have been overlooked by all, and yet he was bold to say it was the most important of any; he alluded to the diffraction caused by the head of the observer, or by the box or case in which it was proposed to encase it or himself. The effect of this diffraction upon the performance of the instrument would become more injurious also the larger the profile of the object which stopped off the light. Under all these difficulties, he had come to the conclusion that all attempts at viewing the direct image must be abandoned. He then turned his attention to prismatic reflexion, in which comparatively much less light was lost. But he found it impossible to obtain large and sufficiently well-formed prisms to insure the best action. But having obtained a very fine prism of a small size by a distinguished optician, he determined to try it. This required the prism to be placed much nearer to the apex of the cone of light reflected from the great speculum (F), and then the eye-piece required to be of such a form as greatly to diminish the field of view, a matter of the most serious import in the researches of the nebulæ in which he was engaged. This difficulty, however, he had surmounted by first using the larger reflector (B) to examine an extensive field of view, though less perfectly,—and then, by a simple contrivance, turn it aside out of the cone of light, and more minutely examine the limited field of view afforded by the prismatic reflexion. Yet after all, he found this most injurious to the work of making accurate drawings of the appearances.

But another still more serious difficulty is fatal to this mode of reflecting,—namely, that although guided by the research of M. Jamin, and using the formulæ afforded by Cauchy, and every other formula he could conceive or arrive at the knowledge of, both as to polarized light and aberration, he had altogether failed in making this eye-piece achromatic; and if any mathematician of the Section could supply him with the means of securing this result, he would feel himself under great obligations to him, and would cheerfully furnish him with the precise

data of the problem. Under these circumstances, he perceived that there was no resource but to improve metallic plane reflectors as much as possible. Now, it was well known that in reflexion by silver much less light was lost than by any of the other metals,—but, unfortunately, this metal was so soft, that great difficulties presented themselves in giving it the requisite degree of high polish. He had tried by the electrotype process to procure a surface with a high polish by depositing silver on a surface of speculum metal, and treating it by the same process as that used by the distinguished officers engaged in the Trigonometrical Survey of Ireland. But, unfortunately, he soon found that, use what precaution he would, either there took place an adherence of the deposited silver to the surface on which it had been deposited, or the polish was rendered imperfect by the means resorted to to prevent this. He tried copper similarly, which did not adhere, but produced a high degree of polish,—but of course its color and other properties rendered it inadmissible as a reflector. He then determined to endeavor to grind and polish a plane surface of silver, the softness of that metal having heretofore, however, caused the attempt to fail in the hands of the most experienced who had tried it. The processes of grinding and polishing are essentially different: in grinding, the substance, whether emery or other powder, must run loose between the substance which is used to rub it against the other and that which is to be ground; and he soon found that he could not use emery or any other grinding powder for bringing a surface of silver to a correct form, —for, from the softness of the metal and the unequal hardness of its parts, the emery was found to confine its action to the softer parts, leaving the harder portions in elevated ridges and prominences, something in the way that the iron handle of a pump which has been long and much used may be observed to be worn away. Hard steel he found he could bring to a very true surface, and even impart to it a high degree of polish; but the quantity of light it was capable of reflecting was by no means sufficient, nor could he succeed in imparting to the surface of silver by compression with highly-polished steel surfaces the evenly and highly-polished surface requisite for his purpose. At length, he found that he could by the use of good German hones grind surfaces of silver perfectly true, and he had now no doubt that he could with safety recommend for that purpose as the best material the blue variety of the German hone.

The next point was, to polish the surface to a true optical plane reflecting surface. This was by no means so easy a task as may be supposed:—for although our eminent silversmiths do produce surfaces of silver of an extremely brilliant polish, as in the magnificent plateaux and other articles which they turn out, yet if any one will take the trouble to examine these surfaces, they will be found to be so irregular though highly polished, as to be entirely unfit for producing correct images by reflexion. And it is a singular fact that, although in the first part of the process of polishing, chamois leather of the finest kind was used to rub the rouge on the silver surface, yet the finer finishing polish had always to be communicated by the human hand. Nor would the hand of every individual answer:—the manufacturer had to select those with the very softest and finest grain,—nor would the hand of

perhaps one in every twenty of the persons employed answer for thus giving the final finish. But it was obvious that the irregular action of the human hand would by no means answer the end he had in view. Suffice it to say, that at length, after many fruitless trials, he had succeeded in producing a polishing surface which seemed fully to answer the purpose by exposing spirits of turpentine to the continued action of air, or by dissolving a proper quantity of resin in the spirits of turpentine, and by means of this varnish applying the rouge to the same description of polishing substance which he used in polishing the speculum metal, and which he had heretofore so frequently described. By the use of this polishing substance he had produced a plane surface of silver which, as far as the photometric means he had within his reach would enable him to measure the light before and after reflexion, did not lose in that action seven parts of the hundred, and which, tested in the manner which he usually adopted, defined admirably.

The Astronomer Royal begged to know how Lord Rosse secured the plane form of the surface in grinding and polishing. The Earl of Rosse replied that, as to the mode of grinding, it was that commonly adopted for producing accurately flat surfaces. But the mode in which he tested it was peculiar. It was this:—a watch dial was placed before a good telescope, and as soon as the eye-piece was accurately adjusted to the position of most distinct vision, the plane mirror was placed in front of it at an angle of 45°, and the watch-dial was moved round by a simple contrivance to such a position as that its image should very nearly occupy the place it had been just removed from. If now the adjustment of the telescope for distinct vision remained unchanged, the proper form had been attained; but, if by drawing out the eye-piece more distinct vision was obtained, it was concluded it had received a convex form,—if on pushing it farther in it gave the image more distinct, then it was concluded the mirror had received a concave form. Prof. Chevallier wished to know whether Lord Rosse intended to form the great speculum similarly of silver. The Earl of Rosse replied that he had at present no expectation of doing so. That it was a very different matter to grind and polish a speculum of a few square inches surface—which could be done by a small machine worked by hand, and from which to the eye-piece the light had to travel but about three feet—to executing the same operations over the surface of a speculum six feet in diameter, and from which the light after reflexion had to travel a distance of fifty-three feet. For Newton, with his usual sagacity, had long since shown that any error in the form of the object speculum of a reflector was a much more serious injury to the performance of the instrument than an equal error would be in the plane speculum,—and that for the identical reason he had just pointed out.

2. *On a New Method of determining the quantity of Hygrometric Moisture in the Air;* by Dr. Andrews.

In the absence of Dr. Andrews, Prof. Stevelly made this communication. Dr. Andrews had found on trial that several powders when well dried, would rapidly, effectually and completely take up the moisture of damp air passed through them, as effctually as the fused chlorid of calcium, which is too troublesome in the making, preserving

and using for common use. For instance, he had found that well dried oxyd of manganese—and a still more universally obtainable substance, powdered alabaster or sulphate of lime, as dried and prepared by plasterers, or by those who make casts—being inclosed in a small syphon, a measured bulk of air passed through either, at a very quick or at the slowest rate, would be so effectually deprived of all its hygrometric moisture, that another syphon filled with coarser fragments of fused chlorid of calcium gained no weight sensible to a balance which turned with the one-thousandth part of a grain,—the measured portion of damp air being in succession drawn through the syphon containing the alabaster and that containing the fused chlorid of calcium. The apparatus contrived by Dr. Andrews—a drawing of which Prof. Stevelly exhibited and explained—consisted of a gasometer whose bell was attached as a counterpoise to the weight of a Dutch clock sufficiently heavy to work it. By this a measured volume of air was drawn through a tube leading from the open air through the syphon containing the absorbent powder, which was attached to it by collars of caoutchouc, so that after the air had passed through, the syphon could be readily detached, weighed, and the gain of weight by the absorption of the moisture thus determined. In this way he was able in widely various hygrometric states of the air to test the indications of Daniel's and other hygrometers,—to determiue the correct relation between the depression of the wet bulb and the dew point—and even to use the apparatus itself as a simple integrating hygrometer by which the total quantity of vapor contained in a measured volume of air drawn through the apparatus, say during twelve hours, at a uniform rate, may be actually determined by weight.

3. *On the Cause which maintains Bodies in the Spheroidal State, beyond the Sphere of Physico-chemical Activity;* by M. Boutigny.

M. Boutigny referred to his former communications and well known experiments on the peculiar state induced in liquids when in contact with very hot metals, and regretted he had not the means for exhibiting the experiments, as they required apparatus he had not at command in the Section, such as for the application of the spheroidal state of water to the purposes of the steam-engine. He referred to the experiments first shown at Cambridge, and their extension since to explain some of the effects of ancient oracles. Alluding to the disputed points in the explanation of his experiments as to the repulsion of metals and fluids, and whether the effects were entirely or not to be attributed to the properties of the thin stratum of vapor, Prof. Boutigny proceeded to show by experiment that when platinum wire was coiled up in the form of a flat spiral and made hot, and ether or alcohol fluid placed on it, in the spheroidal state, the liquid would not pass through between the spaces, while the vapor readily did so.

A conversation ensued on the subject of M. Boutigny's showing the capability of the human hand to pass through red-hot molten metal without injury; and by the prompt kindness of Messrs. Ransomes & May, the experiment was arranged to take place at 7 o'clock in the evening. Accordingly at that hour the members of the Chemical Section had the opportunity of seeing M. Boutigny pass his hand through

the stream of liquid red-hot iron as it passed from the furnace, and afterwards scooping out portions of iron from the casting ladle, until the fluid sunk to the mere red-hot fluid state, when danger might be apprehended from the falling of the temperature causing the iron to adhere.

4. *On Earthquakes;* by Mr. MALLET.

Mr. Mallet presented his "Second Report on the Facts of Earthquakes," and stated the result of his experiments for the "Determination of the Limits of Earthquake Wave Transit," for which the proposed plan was explained last year. The rate of transit was expected to be the least rapid in sand, and most in some elastic, homogeneous, crystalline rock. Accordingly, a mile was measured on the sands near Dublin, and a cask of powder buried at one extremity,—the interval between the firing of the powder and the indication of the shock at the other station, as registered by Wheatstone's chronograph, gave a rate of 965 feet per second, as the average of ten good experiments. A shorter base was measured on the granite, and shocks produced by borings three and a half inches diameter and eighteen feet deep, in which as much as twenty pounds of powder were exploded. The experiment was repeated twenty or thirty times,—and where the granite was most shattered the shock arrived at the rate of only 1,299 feet per second; under the most favorable circumstances, where the rock was most homogeneous, the impulse travelled at 1,661 feet per second. In many of the most celebrated earthquakes, clocks have been stopped, and thus indications afforded of the rate at which the shocks travelled. In the Lisbon earthquake of 1761, the shock travelled to Corunna at the rate of 1,994 feet, to Cork at the rate of 5,280 feet, and to Santa Cruz in Barbary at 3,261 feet per seeond. The great Cutch earthquake, in 1819, stopped the clocks in Calcutta, and showed a rate of 1,173 feet per second. The Nepaul earthquake of 1834 stopped numerous chronometers, and the rate of transit from the assumed centre to various places showed a rate varying from 1,000 to 3,000 feet per second. These rates were all lower than would be expected, considering rocks as homogeneous substances; and perhaps, after all, the earthquake shocks might follow a law altogether different from that of *sound* waves.

Mr. Mallet then called attention to the Catalogue of Earthquakes, amounting to nearly 6,000, and—exhibited diagrams in which the amount of earthquake disturbance in all known times was represented by curved lines; these showed a slight indication of paroxysmal periods, with intervals of half a century or more. Another diagram representing the months in which the shocks occurred, showed a maximum in December and January. Mr. Mallet then exhibited a map of the distribution of earthquakes, formed by coloring the area of each successive earthquake recorded in the Catalogue, and one wash of color being carried over another, produced tints of intensity proportioned to the frequency of these visitations. On this map the regions of Guinea, Abyssinia, and Madagascar were uncolored, no recorded earthquakes having occurred in them; Greenland was uncolored, because the slight shocks felt there might have been occasioned simply by movements of masses of ice upon the coast. Special attention was called to one spot

in the Atlantic near the Line, and midway between Guinea and Brazil; vessels passing this tract almost always experienced shocks,—the soundings were extremely variable, some being obtained at 400 fathoms, whilst at very small distances the depth was exceedingly great, as if the bottom was formed by a group of volcanic mountains. The connection between earthquake lines and volcanic lines was very apparent on this map; but some earthquake regions, like Central Siberia and a tract extending from India to Bohemia, display very little volcanic energy. On a diagram section of the globe, the most distant points at which great earthquakes had been felt were connected by straight lines; these showed what very large portions of the mass of the earth might have been affected supposing the original impulses to have been communicated at very great depths. Lastly, Mr. Mallet called attention to the great want of bibliographical catalogues in all public libraries, which rendered the search after earthquake literature a work of enormous labor.

Mr. Hopkins remarked that whilst he placed no faith in such indications as those of earthquakes being more frequent in winter, they were yet very curious; and it was not yet known how much might be due to the influence of apparently trivial causes. With regard to the condition of the interior of the globe, and looking at the earthquake map, he was still disposed to lean towards the hypothesis of the existence of internal lakes of fluid, more or less disconnected, in preference to a fluid central nucleus; earthquake shocks would be propagated to great distances beyond the boundaries of the agitated fluid.

5. *Report on the Physical and Economical Effects of the Destruction of Tropical Forests in British India;* by Dr. H. Cleghorn.

Viewing the question in its physical relations, the author drew attention to the climatic influences of the denudation of the surface of the country; he adverted to the known phenomena of decrease of springs, and the consequent diminution of river supplies, as results of the entire removal of the woods which are collected on the highlands, where such supplies usually originate;—and while distinctly admitting that wherever the wants of an advancing population require the clearance of forest lands, whether for food or the protection of health, such clearance is to be encouraged, he at the same time insisted strongly on the propriety of exercising a careful vigilance, under well defined regulations, in all cases in which the above mentioned causes are not in operation. In considering the economic relations of the question, Dr. Cleghorn availed himself largely of the labors of various distinguished and intelligent observers to illustrate the effects of the existing imperfect system of protection and superintendence. He recorded evidence as to the state of the forests in Malabar, Canara, Mysore, Travancore, the Tenasserim provinces, the Indian Archipelago, and the wooded tracts which skirt the base of the Himalayas. From this evidence, it appears that neither the government nor the community derive from the forests all those advantages which they are calculated to afford. There are numerous products of which the value is known and appreciated,—but which are collected in ways so rude and wasteful, that it is doubtful whether more of them are not lost in the process than are brought

into commerce. There are others, perhaps more numerous, which are known only to the scientific observer; to these, it has been the endeavor of the Committee to direct attention. It is no unauthorized inference, that in the depths of those great forest masses there may still be many substances which only await recognition by instructed eyes to take their places among the valuable agents of manufacturing industry, social comfort, or medical practice. To correct the first, to extend the second, and to discover the third, are the leading points to which the Committee would direct attention; and they have endeavored to furnish to the best of their ability information calculated to advance each of those interesting ends. The general conclusions which appear to the Committee to be warranted by the various statements of fact and opinion, may be summed up as follows:—1. That over large portions of the Indian empire there is at present an almost uncontrolled destruction of the indigenous forests in progress, by the careless habits of the native population. 2. That in Malabar, Tenasserim and Scinde, where supervision is exercised, considerable improvement has already taken place in the forests. 3. That these improvements may be extended by a rigid enforcement of the present regulations, and the enactment of additional provisions of the following character,—viz. careful maintenance of the forests by the plantation of seedlings in the place of mature trees removed,—prohibition of cutting until trees are well grown, with rare and special exceptions for peculiar purposes,—in cases of trees yielding gums, resins or other valuable products, that greater care be taken in tapping or notching the trees, most serious damage at present resulting from neglect in this operation. 4. That special care and attention should be given to the preservation and maintenance of the forests occupying tracts unsuited for culture, whether by reason of altitude or by peculiarities of physical structure. 5. That in a country to which the maintenance of its water supplies is of such extreme importance, the indiscriminate clearance of forests around the localities whence the supplies are derived is greatly to be deprecated. 6. That, since much local ignorance prevails as to the number and nature of valuable forest products, measures should be taken to supply, through the officers in charge, information calculated to diminish such ignorance. 7. That, as much information which may be of practical utility is contained in the manuscript Reports and Proceedings of the late "Plantation Committee," it is desirable that the same should, if practicable, be abstracted and given to the public.

Capt. Strachey said he could not agree with those who thought that forests had much influence on climate. It was a notion that they encouraged rain,—but it was more probable that rain was the cause of forests. He alluded to districts in India in which the forest vegetation was just in proportion to the fall of rain; being small and diminutive where there was little rain, and abundant and gigantic where there was much rain. In temperate climates forests might produce an effect, —but certainly not in the tropics. With regard to the economical question, there could be no doubt that it was foolish to destroy what was valuable, but we had not the power to arrest the present destruction of forests in India. Mr. Bunbury enumerated several instances where forests did not exist and yet there was much rain, and

others where forests existed and there was little rain. Humboldt was our great authority on this subject, and he had recorded his opinions of the influence of forests on climate. In many districts where forests were cleared and single individuals left, these latter soon died from the want of the influence of their neighbors. Dr. Lankester pointed out that according to the laws of vegetation, plants must be supplied with water in a liquid or vaporous form for their growth, and that all the facts which had been mentioned, and which at first sight appeared opposed to each other, might be explained. That forests did not always grow in rainy districts arose probably from the waters accumulating and forming morasses in which forest trees would not grow. In districts where there was not much rain there might be much moisture in the atmosphere,—rain in general supplied only a very small quantity of the water required by plants. Vegetable physiology afforded no explanation of the effects on climate, attributed by some observers to forests.

6. *On the Great Earthquake experienced in Chile, April* 2, 1851, *from* R. Budge, Esq., to W. Bollaert, Esq., *in a letter dated April* 17, *with Observations by the latter.*

"The earthquake came westward and, of course, from the east; which is sufficiently proved from the circumstance of the water in basins, water-jugs, &c., having been spilt over the east side,—from the clocks whose pendulums vibrated east and west having stopped, while those beating north and south did not,—from walls standing east and west being cracked every way, particularly lengthways,—and from vessels at sea, forty to sixty miles off the land, having felt it at a corresponding hour to the difference of longitude. That it is electric I have also grounds for believing; for it is clear to me that in its course it has instantaneously been stayed,—having turned round things on their base, instead of throwing them down, at an angle of 20°, which not only in my own house, but in others have occurred, showing a circular motion for at least an instant. I had a bust of plaster of Paris and a family medicine chest standing on a chest of drawers moved round in this way, while nothing occurred to my house (built, however, purposely on my own plan for resisting earthquakes) except the removal out of place of a few tiles. A large brick chimney, well stayed above with iron stays, was divided at a certain height from the ground in a horizontal line, and the upper part was twisted round over the lower to about the same angle. In some houses which stood firm from being frame built, though cracked in all directions, the furniture in the rooms, particularly up stairs, appeared as if some fiend had been among them, making them his playthings, some upset, some turned round, &c.

I conceive, therefore, now, that since earthquakes are little felt to the eastward of the Cordillera and severally so to the westward, along the whole range, that chain of mountains must be the point of attraction for the electricity of the atmosphere, and that it then follows westward a proper conductor in the earth, finally leaving the earth in the sea,—for how can a ship at sea be shaken as a house on shore, which has been the case, by any other element, for water being capable of compression if driven against a solid frame, as a loaded ship is, will yield to the resistance, and the blow given to the vessel is different altogeth-

er? I have experienced in this place, as I have stated, three ruinous earthquakes,—that of 1822, which I passed in the house until the back fell, that of 1829, and the present; and from observations on each occasion and now again, particularly as in each case I have been calm and resigned, I think I may be allowed to venture my conjecture in common with others, in which I feel so confident that you are at liberty to submit them to your scientific friends if you please, and if any require further particulars I shall be happy to give them. I may, however, add something more;—the barometer and thermometer indicated nothing, nor was there the least warning of any description; but as invariably occurs after a heavy shock, we had on the third day after a shower of twelve hours' rain, for which I had already prepared, aware of its being the consequence, happen at whatever season it may. I conceive, also, that I have felt less relaxed than before it. I cannot understand all these things unless electricity be the agent; while the atmosphere must be affected in some way to shower down rain at seasons when under ordinary circumstances it does not fall. Santiago (the capital of Chile), Casa Blanca, and Quillota seem to have suffered equally with Valparaiso; and the latter two places worse, while some of the public buildings of the capital are ordered to be pulled down. My wife, who is at that place, mentions every subsequent shock tallying exactly with those here. The shock of 1822 was, however, about double in force and time; and I recollect well it was with difficulty I could stand,—whereas on the present occasion I had no trouble. On that occasion, the sea in the Bay of Valparaiso retired considerably, and was several days in reaching its former level,—while on this no such thing was observed. Your newspapers may make out a different story, but you have here at least correct observations. The country is advancing fast; but it is an awful fact to contemplate that the most massive buildings of the country are the first to yield to the phenomena referred to."

The generally received impression is, that earthquakes have their origin in consequence of violent subterranean action, doubtless of a chemical character. Sometimes the violent eruptions of volcanoes are accompanied by severe earthquakes; and in regard to those of Peru I will instance one of this species, in which volcanic action was accompanied by a terrific earthquake, viz., the eruption in February, 1600, in the mountain range of Ornate, twenty-two leagues from Arequipa. On the 15th of that month the volcano broke out with great fury and the ground was in continual motion. On the 18th, in the evening the movements were more rapid, and at 10 P. M. there was such a shock that it awoke the soundest sleepers, and every five minutes during the night shocks continued. On the morning of the 19th occurred a dreadful shock, of which the Spanish MS. from which I extract this says, 'the movements were now more rapid, and in the twenty-four hours there were more than 200 shocks. The heavens were darkened with clouds of eruptive matter, flashes of lightning were seen, and then there descended much white ashes like a fall of snow, which covered the country around.' On the 28th of the same month happened the most dreadful shock of all. The town of Quinistacas, four or five miles distant from the volcano, with 100 inhabitants, was buried; the town of Ornate

also perished; also many villages in the vicinity were ruined; indeed, the whole country was desolated and ashes fell more than ninety miles distant from the volcano.

The first earthquake I experienced was in 1825 and at Chile. There was a shaking of the ground, some houses and walls fell down, and the water in the (arequias or) water-courses splashed over. I was also in that of 1829, being in Santiago. The commotion commenced on Saturday the 26th of September, at twenty minutes past 2 P. M. The principal undulations appeared to come from the southeast. The great shock was one and a half minutes' duration. Half an hour afterwards there was a shower of rain,—and another slight shower at half-past 4 P. M. The weather, however, before the earthquake was rather inclined for rain. During the night of the 26th there were slight shocks; also some on the following days, Sunday and Monday. On Friday the 1st of October, at half-past twelve, there was another shock,—as well as at half-past one. I went out into the street and found the inhabitants looking at two volcanoes that had broken out,—one in the Dehsa, behind the first range of the Cordillera,—the other in the mountains of Maipu (which last was observed to be in activity just after the earthquake of the 26th), the smoke rising majestically. In Peru I have felt many,—but not very heavy earthquakes. In the province of Tarapaca, lat. 20° south, I have noticed them as occurring two or three times a month,—sometimes accompanied by a slight rumbling noise, which appeared to be subterraneous. But on one occasion, being in the silver mines of Guantajaya, a few miles east of the port of Iquique in the province of Tarapaca (these mines are from 2,000 to 3,000 feet above the sea), at about 100 yards perpendicular depth in the mine a slight rumbling noise was heard, as if coming from the Andes, which increased and then passed onwards to the west; the noise was immediately followed by a horizontal undulatory movement, then a vertical, then a mixture of these, or a shake, and then all was quiet, save a commotion occasioned by some of the loose stones of the mine rolling downwards. My impression then was, and still continues, that earthquakes in the region under discussion (Peru and Chile) originate from volcanic causes. A great part of the Andes is volcanic; Chile abounds in active and quiescent volcanoes; and in the province of Tarapaca there are the volcano of Isluga, with its five craters,—the *Volcancitos* or Water Volcanoes of Puchuttisa,—doubtless many quiescent ones,—on its northern boundary the volcanic group of Gualtieri,—and on its southern the volcanoes of Laguna, Olea, &c. Still, the account received from my friend, Mr. Budge, appears so very circumstantial, that I am induced to give his information regarding the late earthquake in Chile *in extenso*.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Laws of Magnetism.*—Tyndal has studied the laws which govern the attraction of an electro-magnet upon a spherical mass of soft iron. The apparatus employed, consisted of an electro-magnet in the form of a straight bar 10 inches in length and $1\frac{1}{4}$ inches in thickness, and wound with 360 feet of copper wire; this magnet was placed vertically under one extremity of the beam of a balance from which was suspended a sphere of soft iron, in such a manner that when the sphere rested upon the end of the magnet, and the copper suspension wire was tense, the balance beam was exactly horizontal. Weights were placed in a scale pan attached to the opposite end of the beam so as to hold the sphere of iron in perfect equilibrium; in this manner the effect of the weight of the sphere was eliminated. The electro-magnet formed part of a circuit comprising also a galvanic battery, a tangent's compass, and a rheostat. In experimenting, a known weight was placed in the scale pan opposite the sphere, and then by means of the rheostat the force of the current, and consequently the attraction of the magnet, was gradually diminished till the sphere separated from the surface of the magnet; at this instant the angular deflection of the needle of the tangent's compass was noted. In this manner the attractive force corresponding to a given intensity of the current is directly expressed by weight. The principal results obtained by the author in this investigation are as follows:

(1.) The mutual attraction between an electro-magnet and a sphere of soft iron in immediate contact with each other, is directly proportional to the force of the magnet or of the magnetizing current.

(2.) If a constant force be applied to the sphere in a direction opposite to that in which the attraction of the magnet is exerted, the attractive force of the latter must vary inversely as the square roots of the distances in order to hold the sphere in equilibrium when its distance from the magnet varies.

(3.) The mutual attraction between a sphere of soft iron and a magnet called into action by a constant current, is inversely as the distance between the sphere and the magnet.

(4.) The mutual attraction between an electro-magnet and a sphere of soft iron, when the two are separated from each other by a determinate distance, is proportional to the square of the induced magnetism. *Pogg. Ann.*, lxxxiii, 1.

2. *Magnetism of Oxygen gas.*—Plücker has given the results of a comparison of the magnetism of oxygen with that of iron. A glass globe was filled with oxygen of the same tension as the surrounding air. The amount of attraction exerted by an electro-magnet upon this globe was then determined by means of a very delicate balance. The globe was then emptied and filled with a solution of chlorid of iron, and the magnetic attraction again determined in the same manner. The attraction upon the oxygen was found to be to that on the solution

as 8·0678 : 1. To determine the attraction exerted under the same circumstances upon soft iron, a glass vessel was filled with a paste made by grinding pure metallic iron in powder (reduced from the oxyd by hydrogen) with a mixture of fresh lard and wax. The amount of attraction upon this glass vessel when empty was first measured, then the attraction upon the same vessel when filled with the solution of chlorid of iron, and finally the attraction upon the glass when filled with the paste of iron. The amount of attraction upon the glass vessel when empty, was subtracted from the amount upon the vessel when filled with the solution and with the paste. In this manner the magnetism of the solution was found to be to that of the iron as 1 : 230·49; the diamagnetic action upon the lard and wax was found to be so slight that it could be entirely neglected. By combining the two numerical results obtained above, Plücker found the specific magnetism of oxygen to be that of iron as 1 : 285·7. If we refer the specific magnetism of the two substances to equivalents instead of to equal weights, we find for the equivalent of iron a degree of magnetism 81·8 as great as that for an equivalent of oxygen. By the same method Plücker found for the magnetism of sesquioxyd of iron the number 891, that of iron being taken as 1,000,000.—*Pogg. Ann.*, lxxxiii, 105.

3. *Molecular structure of organic bases.*—HOFMANN has communicated to the Royal Society the second series of his researches, on the constitution of the organic bases—researches of which it is impossible to speak without enthusiasm, and which have thrown a flood of light upon this department of organic chemistry. In a former memoir the author demonstrated that the three equivalents of hydrogen in ammonia are susceptible of being successively replaced by the radicals of the ethyl series ($C_n H_{n+1}$) yielding a new series of ammonias represented by the general formula

$$N(X.Y.Z),$$

in which formula X, Y, and Z, represent either hydrogen or an ethyl radical. The combinations of these new ammonias with acids, may be regarded as *ammoniums* in which one or more equivalents of hydrogen are replaced by methyl, ethyl, &c. Hofmann now finds that the *four* equivalents of hydrogen in ammonium are susceptible of replacement by other radicals, so that the most general formula for a large number of organic bases is

$$N(W.X.Y.Z).$$

The author describes in the present memoir eight new ammoniums in all of which the hydrogen is completely replaced by other radicals.

Iodid of ethyl and triethylamine ($N(C_4 H_5)_3$) heated together for a short time in a sealed glass tube, exhibit a powerful reaction, and on cooling solidify into a crystalline mass easily purified by solution in cold water and recrystallization. These crystals are the iodid of *tetrethylammonium* and are represented by the rational formula $N(C_4H_5)_4I$; their formation is expressed by the equation $C_{12} H_{15} N + C_4 H_5 I = C_{16} H_{20} N I$; when rapidly heated they fuse and are decomposed into triethylamine and iodid of ethyl, which again unite in the receiver to form the original compound. The new iodid perfectly withstands the action of a concentrated solution of caustic potash; treated with solutions of the salts of silver, it readily yields iodid of silver and salts

of the oxyd of tetrethylammonium. The oxyd of the new base $N(C_4 H_5)_4 O$ is easily obtained by digesting the iodid with oxyd of silver in slight excess and filtering, when a clear and colorless solution of the new oxyd passes the filter. As thus prepared the liquid exhibits the strongest analogy to the caustic alkalies potash and soda, it possesses a pungent bitter taste, when concentrated it acts upon the epidermis which it destroys like caustic potash; like this too, it saponifies fats; converts furfuramide into furfurine; decomposes oxalic ether into oxalic acid and alcohol; expels ammonia from its salts even in the cold, and may be substituted for potash in Trommer's well known test for sugar. In its action upon metallic salts the new oxyd is also exactly analogous to caustic potash; it yields however no amalgam corresponding to the well known butyraceous ammonium compound. When evaporated upon the air-pump over sulphuric acid and lime the oxyd may be obtained dry, and even crystallized in long hair-like needles; the dry mass appears to be the hydrate $N(C_4 H_5)_4 O, HO$ corresponding to the hydrate of potash KO, HO. A concentrated solution of the oxyd of tetrethylammonium is decomposed by boiling, yielding water, triethylamine and olefiant gas, $NC_{16} H_{20} O, HO = NC_{12} H_{15} + C_4 H_4 + 2HO$. The salts of the new base are mostly very soluble and even deliquescent; the double chlorid of platinum and tetrethylammonium crystallizes in beautiful octahedrons. The other new ammoniums described by Hofmann are,

(2.) Methylotriethylammonium,	$N.(C_4 H_5)_3 . C_2 H_3$.
(3.) Amylotriethylammonium,	$N.(C_4 H_5)_3 . C_{10} H_{11}$.
(4.) Methylodiethylamylammonium,	$N.(C_4 H_5)_2 . C_2 H_3 . C_{10} H_{11}$.
(5.) Phenylotriethylammonium,	$N.(C_4 H_5)_3 . C_{12} H_5$.
(6.) Methylethylamylphenylammonium,	$N.C_4 H_5 . C_2 H_3 . C_{10} H_{11} . C_{12} H_5$.
(7.) Tetramethylammonium,	$N.(C_2 H_3)_4$.
(8.) Tetramylammonium,	$N.(C_{10} H_{11})_4$.

all of which of course exist only in combination; among the products of their decomposition by heat, the author describes several new ammonias or nitryl bases not hitherto considered. The oxyd of tetramylammonium when decomposed by heat yields triamylamine and a volatile hydro-carbon, doubtless amylene; oxyd of tetramethylammonium is also decomposed by heat, but the products of the decomposition have not yet been thoroughly studied: finally the oxyds of the ammoniums (3), (4) and (5), all yield olefiant gas when boiled in concentrated solutions. By the action of the iodids of methyl and ethyl upon conine, nicotine and leucoline, Hofmann has obtained new organic bases, one of which—leucoline in which an equivalent of hydrogen is replaced by an equivalent of methyl—may possibly prove identical with quinine, $C_{18} H_7 (C_2 H_3) N + 2HO = C_{20} H_{12} NO_2$.

In conclusion the author directs attention to the important theoretical bearings of the new alkaloids. In the first place it is to be observed that the action of the bromids or iodids of the alcohol radicals upon ammonia, give rise to not less than four distinct groups of organic bases; three of these—*ammonias*—are volatile, the fourth—*ammoniums*—

are fixed. The passage from a volatile to a non-volatile organic base may therefore be simply due to the fixation of a single equivalent of a radical capable of replacing hydrogen; and the production of volatile bases by the action of caustic potash upon the fixed alkaloids, quinine, morphine, caffeine, piperine, naturally encourages the attempt to reproduce the latter from the former by simple substitutions. In the next place the new fixed bases lend the most powerful support to the ammonium theory of Ampère and Berzelius; the oxyds of the new bases perfectly correspond to the hypothetical oxyd of ammonium and are stable; again it has always been urged against the theory of Ampère that in the formation of sal-ammoniac for instance, the hydrogen of the HCl could not be reasonably supposed to leave the chlorine for which it has so powerful an affinity in order to convert the ammonia NH_3 into ammonium NH_4; moreover in the action of lime upon sal-ammoniac we must, according to the ammonium theory, suppose that the chlorid NH_4, Cl is first transformed into an oxyd NH_4, O, then this oxyd is resolved into ammonia and water. Now in the action of iodid of ethyl upon triethylamine $N(C_4 H_5)_3$ it is perfectly certain that ethyl $C_4 H_5$ actually does leave iodine in order to unite with the triethylamine, and the new iodid readily exchanges its iodine for oxygen when treated with oxyd of silver; finally the new oxyd when heated in solution yields *its* ammonia $N(C_4 H_5)_3$ and its radical oxyd $C_4 H_5 O$, which is then further decomposed. These two stages of decomposition are precisely those which in the ammonium theory appeared most improbable. Lastly, the mode of formation of the new ammoniums and the products of their decomposition by heat, demonstrate, that whatever be the arrangement of the molecules in ammonia or its congeners, the atoms of the compound rearrange themselves whenever the fourth equivalent of the hydrogen or of its replacing radical joins the compound. Thus the oxyd of amylotriethylammonium $N(C_4 H_5)_3 C_{10} H_{11}$ yields $N(C_4 H_5)_2$. $C_{10} H_{11}$ and $C_4 H_4$, not $N(C_4 H_5)_3$ and $C_{10} H_{10}$, clearly showing that an equivalent of ethyl and an equivalent of amyl have exchanged places. —*Philosophical Transactions, Part* 11, *for* 1851.

4. *On Stibmethyl and its compounds.*—Landolt has studied the product of the action of iodid of methyl upon an alloy of potassium and antimony, and has obtained results of great interest and importance. Stibmethyl was prepared by a process precisely analogous to that already employed by Löwig and Schweizer in obtaining Stibethyl, namely, by distilling iodid of methyl with a mixture of antimoniuret of potassium and quartz sand. It is a colorless heavy fluid, possessing a peculiar odor, insoluble in water, soluble with difficulty in alcohol, but readily in ether: in the air it emits thick white fumes, inflames and burns with a white flame, with separation of metallic antimony. Like stibethyl, stibmethyl unites, with oxygen to form a base which saturates two equivalents of acid, and gives compounds with S_2, Cl_2, Br_2, I_2, &c., all of which strongly resemble the corresponding stibethyl compounds. When stibmethyl and iodid of methyl are brought into contact a slight ebullition is noticed, and after a short time the whole solidifies to a perfectly white crystalline mass; these crystals are the iodid of a new radical which the author calls stibmethylium; they are represented by the formula $Sb\,Me_4\,J$. A similar compound $Sb\,Et_4\,J$,

is found by mixing stibethyl with iodid of ethyl, and still a third by the action of the iodid of methyl upon stibethyl, Sb Et_3 Me J. In the present memoir the author confines himself to the description of the compounds of stibmethylium. Oxyd of stibmethylium is readily obtained by adding freshly precipitated oxyd of silver to a solution of the iodid Sb Me_4 I, iodid of silver is formed and the oxyd of the new radical set free; the solution evaporated on the air-pump over sulphuric acid, yields a white crystalline mass which is a hydrate of the oxyd. This hydrate exhibits the most surprising resemblance to caustic potash; it gives a slippery feeling when rubbed between the fingers; is extremely caustic; very soluble in water and alcohol, but insoluble in ether; it attracts carbonic acid rapidly from the air and the carbonate formed is decomposed by lime water, the base being again set free. Heated in a glass tube closed at one end, the oxyd gives off vapors which inflame in the air, metallic antimony being set free, but by cautious heating the base may be volatilized unchanged. In its relations to metallic salts the oxyd of stibmethylium agrees perfectly with the alkalies, potash and soda. The author describes further an acid and a neutral sulphate of the new base, a nitrate, carbonate, iodid and chlorid; these are all colorless, crystalline and bitter tasting salts, and are stated—though without measurements—to be isomorphous with the corresponding potash compounds.—*Ann. der Chemie und Pharmacie*, *April*, lxxviii, 91.

[Note.—The extraordinary analogy which exists between the compounds described by Landolt, and the new ammoniums of Hofmann can scarcely fail to attract the attention of the reader. The parallelism between tetramethylammonium and stibmethylium appears to be complete; the mode of formation of the two is the same; their chemical relations are the same, and the products of their decomposition appear also to be perfectly analogous; thus we have

$$N(C_2H_3)_3 + C_2H_3I = N(C_2H_3)_4I$$
$$Sb(C_2H_3)_3 + C_2H_3I = Sb(C_2H_3)_4I,$$

again we have in the case of the decomposition of $N(C_4H_5)_4O$ by heat $N(C_4H_4)_4O = N(C_4H_5)_3 + C_4H_4 + HO$,

and from Landolt's partial investigation it would appear highly probable that we have under the same circumstances

$$Sb(C_2H_3)_4O = Sb(C_2H_3)_3 + C_2H_2(?) + HO.$$

The isomorphism of Sb $(C_2H_3)_4$ with potassium would be of great interest if proved by careful measurements, and the formation of a new series of alums in which potassium is replaced by N $(C_2H_3)_4$ or Sb $(C_2H_3)_4$, would be a simple and decisive test of this point. It is to be clearly borne in mind that the compounds Sb $(C_4H_5)_3$ and Sb $(C_2H_3)_3$, stibethyl and stibmethyl, although corresponding with ammonia in *formula*, do not do so in chemical relations, since they unite directly with 2 equivalents of oxygen to form basic oxyds saturating 2 equivalents of acid, so that we have Sb $(C_5H_4)_3O_2$ and Sb $(C_2H_3)_3O_2$. It is therefore so much the more worthy of notice that these radicals, when combining with an additional equivalent of methyl or ethyl, yield *ammonium* bases, and Hofmann reasoning in favor of the ammonium theory receives a new support. Landolt's memoir, in several particulars exhibits a want of thoroughness, and the analytical data for

his conclusions are not stated. It would appear however certain that there are at least two classes of ammoniums, nitrogen ammoniums and antimony ammoniums, or N (W.X.Y.Z) and Sb (W.X.Y.Z), and it can hardly be doubted but that the progress of science will make us acquainted with phosphorus, arsenic, and perhaps even bismuth ammoniums, P (W.X.Y.Z), As (W.X.Y.Z), and Bi (W.X.Y.Z).

W. G.]

5. *Selenio-cyanogen and its compounds.*—CROOKER has described a series of salts containing selenium in the same form in which sulphur exists in the sulpho-cyanids. Selenio-cyanid of potassium is obtained by fusing selenium with ferrocyanid of potassium: it crystallizes in needles resembling the sulpho-cyanid is deliquescent and easily decomposed; its formula is K Cy Se_2. With the salts of various metallic bases the selenio-cyanid of potassium gives precipitates; the lead salt is decomposed by HS and yields selenio-cyanhydric acid H Cy S_2 as a strongly acid easily decomposed solution. The other compounds possessed, beyond the fact of their existence, no special interest.—*Ann. der Chemie und Pharmacie*, lxxviii, 177.

6. *Propion.*—MORLEY has described propion or the acetone of propionic acid. Propion is readily obtained by the dry distillation of propionate of baryta, the reaction being expressed by the equation

$$Ba\,C_6\,H_5\,O_4 = BaO\,.\,CO_2 + C_5\,H_5\,O.$$

It is a colorless or pale yellow liquid, of an agreeable odor, lighter than water with which it is not miscible; it is easily inflamed and burns with a pale blue flame; its boiling point is 100 C., and it is soluble in every proportion in alcohol and ether. With fuming nitric acid propion yields propionic and apparently no other acid.—*Ann. der Chemie*, lxxviii, 187.

7. *Iodid of Nitrogen.*—GLADSTONE has succeeded in determining the true constitution of the so-called iodid of nitrogen and has shown that Bineau's formula NHI_2 is correct. The black powder obtained by the action of ammonia upon an alcoholic solution of iodine, was suspended in water and a current of sulphuretted hydrogen passed through till the solution became colorless and smelt strongly of HS. After gentle heating and filtration, the iodine was determined as iodid of silver, and the ammonium estimated in the usual manner. The ratio of the nitrogen to the iodine in equivalents was found to be as 1 : 2. The same result was obtained by means of the reaction expressed by the equation

$$NHI_2 + 4SO_2 + 4HO = NH_3 + 2HI + 4SO_3$$

the ratios of N, I, and S being found to be 1 : 2 : 4. [It will be remembered that Wurtz obtained an analogous formula with methylamine and iodine, viz. $N(C_2\,H_3)I_2$, where methyl replaces hydrogen in NHI_2].—*Ann. der Chemie und Pharmacie*, lxxviii, 234.

8. *Alcohol of caprylic acid.*—BOUIS has prepared what appears to be the alcohol of caprylic acid $C_{16}\,H_{18}\,O_2$, by the action of a concentrated solution of caustic potash upon castor oil; a volatile oil passes over while sebacic acid remains in combination with potash. The reaction is expressed by the equation

$$C_{36}\,H_{34}\,O_6 + 2(KO, HO) = C_{30}\,H_{16}\,O_6, 2KO + C_{16}\,H_{18}\,O_2 + 2H,$$

from which it appears that the decomposition of ricinoleic acid, $C_{36}\,H_{34}$

O_6, is the source of the new alcohol. What becomes of the other constituents of the oil, glyceryl, &c., is not stated. The new alcohol is a transparent oleaginous liquid, having an agreeable aromatic odor; its density is 0·823 at 19° C., it boils without decomposition at 180° C., under a pressure of 760^{m}. The density of its vapor is 4·49=4 vol. Sulphuric acid dissolves the oil and yields soluble salts of lime and baryta; on heating, the acid transforms the alcohol into a hydro-carbon isomeric with olefiant gas: this carburet is very fluid, lighter than water, burns with a beautiful flame and boils without decomposition at 125° C.: its formula is C_{16} H_{16}; the density of its vapor is 3·86=4 vol. Fused chlorid of zinc produces with the new alcohol various isomeric carburets of hydrogen; chlorid of calcium dissolves in it and furnishes beautiful transparent crystals which are again decomposed by water or heat. Acetic and chlorohydric acid transform the alcohol into ethers which have an agreeable aromatic odor; nitric acid when dilute converts the oil wholly into a volatile liquid acid, but the prolonged action of the acid gives pimelic, lipic, succinic and butyric acids. Potash lime at a temperature above 250° C., converts the oil with disengagement of hydrogen into a volatile acid which remains combined with the potash, doubtless C_{16} H_{16} O_4. The author promises a more complete study of the new alcohol; the preliminary notice contains much that is obscure and uncertain.—*Comptes Rendus, Aug.* 11*th*, xxxiii, 141.

9. *On the new metal Donarium.*—In the zircon syenite of Brevig in Norway, Bergemann has discovered a mineral which upon examination proved to contain the oxyd of a new metal, Donarium; the mineral in question is a hydrated silicate of donarium [see p. 387], and is represented by the formula Do^2 O^3 SiO^3+2HO; it is readily decomposed by chlorohydric acid, and after the separation of the silica in the usual manner, ammonia precipitates from the solution a hydrated oxyd of donarium as a white voluminous mass, which upon drying becomes gradually yellowish and reddish yellow. The precipitate contains a little iron from which it is freed by ignition and digestion with chlorohydric acid which dissolves the iron; the oxyd may then be dissolved by long digestion with sulphuric acid; from the sulphate the pure hydrate is obtained by precipitation with ammonia white but becoming yellowish on drying; it is readily soluble in acids; in chlorohydric acid without evolution of chlorine. Metallic donarium was obtained from the oxyd by heating with potassium; the decomposition takes place rapidly with evolution of light, and the metal is separated as a coal-black heavy powder, which under the burnisher assumes a metallic lustre which it retains for several hours even in moist air. Particles of the metal scattered in the flame of a lamp burn with a reddish light to oxyd. Chlorohydric acid hot or cold has no action on the metal; nitric acid acts slowly on heating; nitro-muriatic acid oxydizes it rapidly to red oxyd of which a small portion is dissolved. The anhydrous oxyd obtained by strong ignition of the hydrate is of a very deep red color; its density is 5·576; it is soluble only in sulphuric acid after long digestion and subsequent dilution with much water. The solutions of the hydrated oxyd in nitric and sulphuric acids are colorless; that in hot chlorohydric acid yellow, which color however vanishes upon cooling. Potash, soda, and ammonia, give with solutions of the oxyd white precipitates which are insol-

uble in an excess of the precipitant. Alkaline carbonates yield precipitates soluble in an excess of the precipitant; the solution in carbonate of soda is not precipitated by boiling; that in carbonate of ammonia, on the contrary, is completely precipitated, and the precipitate is not again dissolved in an excess of the carbonate.

Oxalic acid produces in a neutral or acid solution, a thick white precipitate which is insoluble in free oxalic, but soluble in a large excess of chlorohydric acid with the aid of heat. A concentrated solution of sulphate of potash gradually produces a precipitate which is however again dissolved by more water or by HCl. Ferrocyanid of potassium produces in a neutral solution of oxyd of donarium, a nearly flesh colored precipitate soluble in acids. Carbonate of baryta precipitates the oxyd completely in the cold. Sulphid of ammonium produces in solutions of donarium a dark green flocky precipitate which is insoluble in an excess of the precipitate: HCl decomposes it with evolution of sulphydric acid gas. Red ferrocyanid of potassium, tincture of gall-nuts and sulphydric acid produce no precipitate; organic substances, such as tartaric acid, almost entirely prevent the precipitation of the oxyd by caustic alkalies. The oxyd of donarium is not rendered soluble by fusion with caustic or carbonated alkalies; fused with bisulphate of potash, however, a flocky matter is obtained which is soluble in excess of water, and appears to be the double sulphate of donarium and potash. Before the blowpipe the oxyd of donarium exhibits no very characteristic reactions. With soda it forms a globule in which the particles of the oxyd appear undissolved; with borax and the double phosphate it gives a yellowish pearl which becomes colorless on cooling and in which the particles of the oxyd are easily recognized. A mixture of the hydrated oxyd and sugar was ignited and then a current of dry chlorine passed over the mass heated to redness in a glass tube; white vapors were formed which condensed to a voluminous mass perfectly soluble in water, these were doubtless the anhydrous chlorid $Do_2 Cl_3$. The equivalent of donarium was determined by an analysis of the sulphate which gave for the metal 997·4, upon the assumption (which the author considers highly probable) that the oxyd is a sesquioxyd.—*Pogg. Ann.*, lxxxii, 561. W. G.

10. *An Account of an apparatus for producing Attrition between the Surfaces of Siliceous Stones in Vacuo, or in Gaseous Media, and for Determining whether the Consequent Odor and Corruscations are due to Ozonification;* Communicated at a meeting of the Franklin Institute, April 17, 1851, by Dr. Hare, Member of the Institute, Emeritus Professor of Chemistry in the University of Pennsylvania, and Associate of the Smithsonian Institution, (Journal of Franklin Institute).—Dr. Hare submitted to the attention of the meeting, an apparatus for ascertaining whether the phenomena attending the attrition of pieces of silex, when rubbed briskly together, had any thing in common with those ascribed by Schönbein, to a supposed new halogen body, named by him Ozone, and made the following remarks. The odor which results from electrical excitement, or discharges between oppositely electrified bodies, had long been familiar to electricians. This odor is of a nature to recall that of phosphorus to all acquainted with the smell

which this substance has when slowly oxydizing in the air, while to those, unacquainted with the odor of oxydizing phosphorus, the universally known odor of burning sulphur has been cited as an exemplification. Hence, the often repeated allegation of a sulphurous smell being consequent to the passage of lightning. A similar property was likewise observed in oxygen, which had been extricated from water by electrolysis. I observed a like odor about twenty-five years ago, when a large tube, used in the inflammation of explosive mixtures of hydrogen and atmospheric air, was burst by the process; as well as upon other occasions, when similar burstings ensued.

Schönbein, who has attained much celebrity as the inventor of gun cotton, was the first to associate phenomena of the kind alluded to, under one view; and to show that the air which had acquired the odoriferous property in question, however obtained, had certain chemical properties in common. These properties were analogous to those displayed by chlorine, bromine, iodine, fluorine, and cyanogen, which constitute the halogen class of Berzelius; and hence the distinguished investigator conceived that they might be due to some body of that class, which had escaped detection.

To this supposed body he gave the name of "Ozone," from Greek words which signify the production of odor.

As cyanogen is known to consist of two atoms of carbon and one of cyanogen, it would not, *a priori*, be unreasonable that another body should be formed deserving to be ranked in the same class.

Latterly, Schönbein has advanced the idea that ozonification may be owing to a combination consisting of peroxyd of hydrogen and bioxyd of nitrogen, or in other words, of oxygenated water and nitric oxyd. But this inference seems to have been invalidated by an experiment made by de la Rive and Marignac. These distinguished chemists ozonized oxygen by passing electric sparks through the gas, while exclusively occupying a tube in which it had been evolved from chlorate of potassa previously fused, and consequently devoid of moisture.

Hence Berzelius, and other distinguished chemists, deemed it reasonable to ascribe the phenomena to a peculiar state of oxygen.

It had long been known that certain elements were capable of very different states; as for instance, carbon in the forms of tinder, charcoal, anthracite, plumbago, and the diamond.

According to Prof. Draper, chlorine after exposure to the solar rays, becomes more capable of combining with hydrogen under a feeble illumination.

This diversity is displayed in many instances by bodies in what has been called their nascent state, which is assumed just as they escape from combination. Under these circumstances, they will combine with elements for which, usually, they display no affinity. Thus nitrogen, as it exists in the atmosphere, shows no affinity either for carbon or hydrogen, yet when nascent, forms with hydrogen, ammonia, with carbon, cyanogen. On this account I have concurred in opinion with Berzelius, that the phenomena ascribed to ozone may be caused by oxygen in a peculiar state.

It is requisite to mention, that among the tests of the presence of ozonized air, the mixture of starch paste with a solution of iodid of

potassium is the most delicate. This is dependent upon an inexplicable but well known property of starch to be rendered blue by a very minute portion of free iodine. A very small addition of chlorine, by seizing an equivalent portion of potassium, liberates enough iodine to produce blueness in mixture; and, in like manner, a very small proportion of ozonized air, whatever may be its source, renders starch blue by a like procedure.

In like manner, by exposure to ozonified air, strips of paper, drenched with a tincture of gum guaiacum, are rendered blue, as these changes would have resulted from the presence of chlorine, and as neither that nor any other of the known halogen bodies could be present, the agency of some undetected body of that class was reasonably to be inferred.

Having given this preliminary brief sketch of the state of our knowledge respecting ozone, it is time to proceed to explain its connection with the contrivance of the apparatus before us.

It had occurred to me that the smell and corruscations arising from the attrition of siliceous stones, briskly rubbed against each other, might be due to some cause, analogous, if not identical, with that to which the phenomena of ozone are indebted for their existence.

Nothing could be more unaccountable than this odor. That it cannot be due to any organic matter entering into the composition of the quartz must be evident; in the first place, because the smell is produced by the purest and most transparent specimens of rock crystal in the regular form, and in the second place, because ignition to bright redness does not destroy nor even diminish the property.

One thousand grains of cellular horn stone, or French burr, on ignition as above stated, lost five grains—that is to say, one-half per cent. of its weight, without, however, losing the property of producing light and smell.

It occurred to me that it might help to remove the mystery, were an apparatus constructed by which the attrition of siliceous masses might be made more efficaciously than could be effected by an operator unaided by mechanism. Having suggested this idea to my friend, Prof. Henry, he said that I might have such an apparatus constructed at the expense of the Smithsonian Institution. The apparatus, which is before the meeting, was made accordingly.

Two pigmy mill-stones, each seven inches in diameter, made of cellular horn stone, known vulgarly as French burr, and resembling those used in grist mills, were procured and supported as in the usual way, one above the other; excepting that the upper one hangs by means of a bolt upon a spiral spring of brass wire, sustained by a cross of iron, resting upon screw nuts, upheld by four iron rods, each inserted at its lower end in a circular plate of cast iron, so as to be equidistant from each other. The surface of the iron plate is turned true, so as to enable it to serve as an air-pump plate. It rests upon four columns, which elevate it from a base board sufficiently to admit of a pulley band and wheel to work in a parallel plane below that in which the plate is situated. There is also room for a lever, from which a stirrup hangs as a support for the spindle of the pulley, on the apex of which plane extended upwards through a perforation in the axis of the plate, the lower mill-stone rests. This spindle passes through a stuffing box, so as

to be air-tight; the stirrup allowing it to retain its perpendicularity, notwithstanding the curvilinear movement of the lever when employed to raise or lower the stone.

The nuts upon which the cross supporting the upper stone has been mentioned as resting, are so used as to render the lower surface of the stone horizontal, while, as it hangs upon a bolt which occupies the axis of the spiral spring, the pressure on the lower stone, when brought into contact with it, may be made as gentle as necessary. The lower stone being balanced on the point of the spindle, is made to turn with it by means of a pin proceeding from its lower surface and another proceeding from the spindle, which operates as a carrier in a lathe.

In order to put the apparatus in operation, the lower stone is made to revolve by means of the pulley, band, and wheel; while, by means of the lever, the stone is so raised as to produce sufficient contact with that suspended above it. Under these circumstances, scintillation and the odor which is the object of inquiry resulted. In no way, however, could I produce the chemical effects of ozone upon iodized starch or guaiacum. On directing a jet of hydrogen between the stones, it took fire forthwith; but I could not, by means of an electrometer, detect any electricity. When the upper stone was removed, and a piece of an old file of a large size made to scrape over the surface of the lower stone, a conducting connexion between the file and an electrometer was productive of no electrical indication.

The plate being ground to fit a large receiver, the stones were in successive experiments made to revolve in vacuo, in hydrogen, and in a vacuity previously replete with this gas, without any diminution of the luminous phenomena. These, it seems from the inflammation of the jet of hydrogen, constitute a simple case of ignition. During the collision of flint with steel, a portion of the metal being struck off, takes fire, and thus is enabled to convey ignition to tinder or punk. The incapacity of two pieces of quartz to produce fire in like manner, arises from the incombustibility of the particles struck off from them, which consequently cool before they meet any mass with which they are not in contact at the moment when the ignition supervenes.

As the burr stones are opaque, the light is much less advantageously seen when they are both employed, than when the upper one is replaced by a comparatively small mass of transparent quartz. The concentration of the frictional force, and the transparency of the mass under which the ignition is effected, makes the corruscations very brilliant in a room otherwise darkened.

So great is the resistance of the surfaces of the stones when brought into revolutionary collision, that the maximum effect which they are capable of producing, would require more force than can be communicated by the human power, through a single hand actuating the stones by means of a wheel, pulley, and band.

Of course cog wheels might be resorted to, and the power of steam or that of Professor Page's electro-magnetic machine, employed to obtain a greater effect. I have lately been informed, that in English potteries where flint is employed as an ingredient in the ware manufactured, the grinding of this material is productive of an intolerable fœtidity. In an atmosphere thus imbued with fœtidity, chemical effects ought to

be observable if there be any connexion between the source of this fœtidity and that produced by ozonizing agents.

It is long since it occurred to me, that as the phenomena of light, under all the various hues which it is capable of producing, are ascribed to the undulatory affections of an ether pervading the universe; so the still greater variety of odors which influence our olfactory nerves, may be due to vibratory agitation of the same medium.

Consistently it may be conceived that the odor produced during ozonification, during the attrition of quartz, is due to an odoriferous etherial agitation.

II. Botany and Zoology.

1. *Note on the Vegetation of the Coal Period;* by Mr. J. E. Teschemacher, (communicated for this Journal.)—In 1843 my attention was first attracted to the remains of vegetables in the anthracite coal from Pennsylvania; by the year 1846 my collection of specimens was very numerous, and in 1847 I exhibited a small portion of them before the American Society for the Advancement of Science, at their annual meeting in Boston.

In 1846, the Natural Hist. Soc. of Haarlem, in Holland, adjudged a prize to Dr. H. R. Gœppert, professor in the University of Breslau, for a most elaborate and well written dissertation in reply to the prize question proposed by them,

"Whether the beds of coal were composed of plants which grew on the spots where these coal beds now exist, or whether the vegetation grew in other places, and was floated or brought there by other means."

This dissertation, with between 30 and 40 plates, was published at Haarlem in 1848, and has been recently added to the library of the Nat. Hist. Soc. of Boston, from the funds left by James Lloyd which were in the possession of the Republican Institution, and were generously devoted by the members, to the diffusion of science, by the presentation thereof to the Nat. Hist. Soc. for the purchase of the most recent sterling works in its several departments.

From this masterly dissertation it appears that Dr. Gœppert, for the purpose of elucidating this subject, had been pursuing the same course with the coal from various beds in Germany, as I had with those of Pennsylvania. And although the main question has received the same solution from both, namely, that the plants grew where the beds of coal now exist, and were solidified amongst other conditions under that of absolute rest, yet upon some minor points we differ, and I believe that the extent of the beds from which my specimens have been taken, has afforded much more varied appearances than have as yet met his eye.

I should not attempt by any discussion at present to alter the views of Dr. Gœppert, unless I could exhibit to him my specimens, for many of my impressions were at first nearly the same as those he has expressed; and it was only by the reiterated and close examinations of fresh specimens that I was led step by step to change my opinions. In fact, without the inspection of regular series of specimens, presenting various details, it is impossible to arrive at satisfactory conclusions on many points of this occult subject, and it has several times occurred that a

single specimen has thrown unexpected light, not obtained by the inspection of fifty others of nearly the same appearance.

As it is, the questions in doubt are much more numerous than those which appear settled. One of the characters which seems to have escaped him is that of the fissures chiefly traversing well defined vegetable surfaces (epidermis). These are from $\frac{1}{2}$ line to $\frac{1}{2}$ inch in depth, describe various curves, or right lines, sometimes parallel lines, and forms of all kinds, they are sometimes filled with siliceous matter and sometimes with a charcoaly mass evidently of different structure to all around. Neither does he seem aware of the *numerous* fossil remains of fungi in the coal, some of these much resembling those which now exist in the siliceous epidermis of the bamboo and the rattan.

I also differ from him in what he considers the annual rings of Araucaria, although my first impressions were similar to his.

My specimens of Sigillaria, Lepidodendra, and Sagenaria are numerous, and there are various appearances, resembling the internal structure of some of these gigantic vegetables, which if they can be recognized as such would cause considerable astonishment. The appearances which Dr. Gœppert has at present probably no idea of, are many and very interesting, but without well and carefully drawn figures, descriptions of them, would be useless. In stating that I differ from so experienced a naturalist on this subject as the learned professor of Breslau, it is far from my intention to impute to him even erroneous views—yet it is only from difference of opinion that truth comes to light, and this is my only desire.

When this subject shall have been taken up and studied by scientific men whose minds are well prepared and who are possessed of sufficient leisure, I am sure that extremely interesting facts and consequences will be developed by their observations.

Boston, Sept. 13th, 1851.

2. *Conspectus Crustaceorum, &c.; Crustacea of the Exploring Expedition;* by JAMES D. DANA.—CRUSTACEA GRAPSOIDEA, (Proc. Nat. Sci., Philad., 1851, p. 247.)—This paper includes descriptions of the following new species:*

Eucrate crassimanus; Macrophthalmus pacificus; Gelasimus nitidus; Helœcius inornatus; Pseudograpsus oregonensis, P. nudus: Grapsus planifrons, G. longitarsis, G. crinipes; Goniograpsus simplex, G. innotatus; Planes cyaneus; Hemigrapsus crassimanus, H. affinis; Cyrtograpsus angulatus; Sesarma obtusifrons, S. obesum; Sarmatium crassum; Cyclograpsus cinereus, C. granulatus; Chasmagnathus subquadratus, C. granulatus, C. lævis; Helice crassa; Acanthopus abbreviatus; Plagusia speciosa, P. glabra; Cardisoma obesum, C. hirtipes; Pinnothera faba; Fabia subquadrata; Halicarcinus pubescens; Hymenicus varius, H. Novi-Zealandiæ, H. pubescens.

2. *Mastodon in Northern Illinois;* by Prof. S. P. LATHROP.—A large tooth of a mastodon in a fine state of preservation has recently been found in the Kishwaukee river, in New Mifford Co., Illinois. It was drawn up by a seine, from near the mouth of the river.

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* For the genera see this volume, page 283.

III. Miscellaneous Intelligence.

1. *Great Exhibition in London.*—The scientific portion of the great exhibition though falling far short of the reasonable expectations of men of science, presents yet many objects of interest and I have thought that a few notes taken upon the spot might prove useful if only as hints to those wishing to purchase apparatus abroad. Of a liberal display of balances for chemical and physical purposes, we have to notice the instruments of Messrs. Deleuil and Collot in Paris, of A. Oertling in Berlin, L. Oertling in London, and the United States balances of Mr. Saxton. Deleuil* exhibits balances of three sizes; the largest or balance for physical researches is intended to bear as much as two kilogrammes in each scale and with this load will turn with one milligramme; it is mounted upon a cast iron base and placed within a large case with glass doors, so that bulky objects, as glass globes, &c., may be conveniently weighed. When the beam rests upon its supports, the pans are also supported separately; in throwing the beam off its support the pans are suspended, their knife edges resting upon agate planes: the index is placed in the centre of the beam and descends to a scale below. The workmanship of the whole instrument is admirable; its price with weights is 1500 francs. The large balances of MM. Collot frères, are very similar to those of Deleuil, differing chiefly in having a glass base instead of one of cast iron. Deleuil's smaller balances for chemical purposes when loaded with 200 or 300 grm., are sensible to half a milligramme; the beam as in the other instrument is of brass; the pans are of platinum suspended by silver wires; they are not suspended from knife edges, but by means of steel hooks resting in stirrups upon the end of the beam, an arrangement which is certainly objectionable. The beam in these balances is divided for a sliding weight but there is no sliding rod as in Oertling's instruments. The assay balances by the same maker deserve the highest praise for workmanship and elegance of construction, they are of steel with an index pointing vertically upward; the whole is admirably arranged and of exquisite finish. A. Oertling of Berlin exhibits also both chemical and physical balances; the former are too well known and too generally appreciated in this country to require special notice; the larger instruments will weigh from one kilogramme to one-half milligramme; their construction is upon the whole similar to that of the chemical balances, the beam being divided and furnished with a sliding rod and weight. There are however two indices or pointers instead of one placed horizontally, one at each end of the beam and each is furnished with an index scale. This arrangement is perhaps advantageous for very large balances where a slight deflection of the beam might occur, but it appears unnecessary and is certainly inconvenient in smaller instruments like those employed in delicate physical investigations. The division upon the beam and the use of a sliding weight appears also unadvisable in balances of this size with which it is rarely necessary to weigh very rapidly, but the principal and serious objection to the construction of Oertling's larger balance lies in the suspension of the pans, which rest

* Deleuil, 8 Rue du pont de Lodi.

constantly upon their knife edges when the beam is resting upon its supports. On the whole, therefore, while doing full justice to the admirable workmanship of Oertling's instrument we must give the preference to Deleuil's larger balance for *physical* investigations, regarding always the smaller balances of Oertling's as superior to all others intended for chemical researches. Of the English balances the only one worth noticing is that of L. Oertling of London; the beam of this instrument is very light and the instrument would appear to be a good one, but its shape is inelegant and the want of the sliding rod arrangement is a serious inconvenience. The Danish, Swedish and Belgian balances do not deserve notice; the superintendent of the U. S. Coast Survey exhibits two balances by Mr. Saxton, a larger and a smaller, but the construction of these is too well known in this country to require description at our hands; they are at least equal in point of workmanship to any which the writer has seen abroad.

Of optical apparatus the display in the exhibition is upon the whole very good. M. Duboscq,* son-in-law and successor of Soleil, exhibits a very fine collection of optical instruments, among which we noticed as of recent introduction, Duboscq's regulator of the electric light, and Jamin's instrument for the study of the phenomena of reflection at transparent surfaces. The Nicol's prisms, rhombs and spheres of iceland spar, and glass prisms executed by Bertrand,† are the finest specimens of workmanship in this department which we have ever witnessed. Of glasses for optical purposes there are many interesting specimens. Messrs. Chance of Birmingham exhibit discs of flint glass eighteen, and of crown glass twenty-four inches in diameter; the flint discs appeared to be of fair quality, but we had no opportunity of examining them closely as to veins and striæ; the crown glass was of bad color, indicating want of purity in the materials. The new French glasses with bases of zinc and baryta are admirable, and of perfect transparency and high refractive power; the discs for optical purposes though not so large as the English ones were of perfect quality, and an opportunity of examining them closely was freely given. Several discs, and prisms of flint glass from T. Daguet of Soleure in Switzerland also deserve notice. The only thermometers and barometers adapted for scientific investigation were those of Fastré;‡ the thermometers are constructed in exact accordance with the method of Regnault, being furnished with arbitrary scales and divided upon the stems themselves: the barometers are constructed nearly upon the plan of Fortui. In connection with these instruments we may mention the straight line dividing engine of Perreaux,§ now generally used in the French physical laboratories. Of these there are two sizes, one for the graduation of lines not exceeding 70 centimeters in length, (price with microscopes for revision 900 fr.) the other for lines not exceeding 45 centimeters, (with microscopes 500 fr., without them 400 fr.) Of the very large number of electric telegraphs exhibited, there were we believe none which employed principles essentially different

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* Duboscq, Rue de l'Odeon, 35.
† Bertrand, Jr., 32 Rue de Bretagne.
‡ Fastré, Rue de l'ecole Polytechnique, 3.
§ Perreaux, Rue M. Lèprince, 14. Paris.

from those now generally known or at all likely to replace the modes of telegraphing employed in this country.

In the departments of electricity and magnetism the instruments of purely scientific interest were rare; we have to notice only a Weber's electro-dynamometer by Leyser of Leipsig, and very powerful steel magnets by Logeman of Haarlem. Schrœder of Darmstadt exhibits a large and admirably executed set of models of crystals in wood; Engel of Berlin has a very beautifully constructed hollow wooden model of the wave surface in biaxial crystals; Nobert of Greisswald, the well known microscope maker, exhibits sets of his ruled glass test plates for microscopes. The philosophical apparatus in the English department is mostly intended for the illustration of lectures, and possesses very little merit even for its purpose. Of apparatus for scientific research there is almost none, if we except the microscopes of Ross and other well known makers. There is however in the English department a considerable display of astronomical instruments, constructed chiefly upon the principle that such instruments are good in proportion to their weight, and not likely to be adopted by those who are acquainted with the works of the German artist mechanicians. The purely chemical portion of the exhibition is almost wholly without objects of interest. There are of course a great number of finely crystallized specimens of alum, bichromate of potash and other showy salts, but these are remarkable only as illustrating the scale upon which their manufacture is carried on. Of photographic pictures there are a countless number upon silver, paper and glass; the American daguerrotype portraits are far superior to any others, but the photographs upon paper exhibited in the French department, especially those of Martens, are beyond comparison the finest specimens of the art; the pictures executed upon glass possess a remarkable softness and richness as well as sharpness of outline. It is to be hoped that this branch of photography will soon receive attention in this country. W. G.

2. *Aurora Borealis.*—Since the grand aurora of November 17th, 1848, (which was distinguished for its great extent, being seen in nearly equal splendor from Odessa on the east to California on the west,) we have had no exhibition of this phenomenon of the highest class, like those which occurred from 1835 to 1839, inclusive; but the late month of September has been signalized by three grand auroras, occurring respectively on the nights of the 3d, the 6th and the 29th. An aurora borealis of the highest class, is distinguished by the presence of all the more striking characters of the phenomenon combined, or at least exhibited in rapid succession, such as arches, streamers, a corona, and waves. Each of the late auroras was characterized by marks of the greatest intensity, especially in the completeness and grandeur of the *corona*, and of *auroral waves;* and that of the 29th was remarkable for passing to a great distance beyond our zenith, presenting a well defined and very luminous arch, whose point of culmination was within 30° of the southern horizon. Below this appeared a dark slaty segment, probably the effect of contrast, since the stars shone upon this black ground with unusual brightness. What is quite unusual, this meteor was visible throughout the southern states, and presented a striking and splendid appearance as far south as Charleston and Savannah.

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3. *On the Earthquake in Calabria;* by E. J. MORRIS, (letter to editors of Washington Republic, dated Naples, Aug. 26, 1851.)—On the 14th ult., the western portion of the continental part of this kingdom, from the northern confines of Calabria to the Roman frontier, was agitated by several calamitous shocks of earthquake. This convulsion appears to have had its origin in the volcanic region of Mount Vulture, about one hundred miles to the southeast of Naples. It is a detached and isolated eminence, three thousand feet in elevation, rising at the point where the Appenine chain terminates on the borders of the Basilicala and Apulia; its slopes and summits are broken into numerous craters, of the action of which no record exists, but which yet bear undoubted evidence of eruptive violence at some remote period.

The city of Melfi, separated from Mount Vulture by a deep ravine, is built upon the summit of a hill, the composition of which is grey lava, intersected by strata of travertine upon layers of ashes, sand, tufa, and decomposed stalactites, all denoting the site of an extinct or dormant volcano. Previous to the first shock, a small stream which runs near the town suddenly disappeared, and the shepherds on the mountain were alarmed by loud rumbling noises beneath their feet. The monks of an adjoining convent, admonished by these phenomena, escaped from their building almost at the moment it was rent in twain.

At the first shock, Melfi, which contains ten thousand inhabitants, was prostrated in the dust, nothing but a few crumbling walls surviving the general ruin. An unknown number of its inhabitants were buried under the falling mass of fabrics; up to the present moment seven hundred dead bodies have been disinterred and others are constantly being found; more than two hundred persons lie in an adjacent hospital, suffering under grievous wounds, while many have been dug out alive from the ruins. Amongst others, a female infant a year old, after lying buried for two days, was brought out living and unharmed, and restored to its afflicted mother, widowed by this same calamity.

The neighboring towns of Atella, Rionero, Barile, and Rapolla, are sufferers by the same convulsion. Rionero is a general wreck, not a sound house remaining—more than a hundred persons have here perished, and as many have been maimed or wounded. In Barile, the only edifice not entirely destroyed is the orphan asylum, while the discovered dead amount to about one hundred and fifty. In the commune of Bari, the towns of Cerato, Minervino, Spinnazzola, Andria and Trani, were all more or less injured. In Canosa, the ancient Canosium, founded by Diomed, and whose walls once enclosed a circuit of sixteen miles, three hundred and seventy-six houses were thrown down. At the last reports the shocks around Mount Vulture continued, and one-half of the city of Venosa, the ancient Venusia, containing six thousand inhabitants, and celebrated as the birthplace of Horace, was destroyed. The mountain provinces of the Abruzzi and of Calabria, where the earthquake of 1783 destroyed three hundred cities and buried thirty thousand human beings, have thus far escaped.

The recent earthquake commenced with a sharp concussion, which was succeeded by an undulatory movement, the first shock being about sixty seconds in duration. At Melfi there were six shocks, the first at $5\frac{1}{4}$ P. M., the second at $3\frac{1}{4}$, the third at $4\frac{1}{4}$, the fourth at 10 P. M., the

fifth at 3 A. M., and the sixth at 7 A. M. At my summer residence in the country, eighty miles from Melfi, the house shook to its foundation, and such was the vibration, that it was difficult to descend the staircase. For ten minutes previous the house dog howled in most dismal tones, the chickens cackled and hurried about as if fleeing from some anticipated danger, and a pair of turkeys rose in the air and flew around the house screaming as if seized by a secret terror, while all the dogs in the neighborhood were in full bay. No damage was done at La Cava, or at Naples, beyond slight cracks in old walls. * * *

The loss of life from the earthquake of the 14th ult., it is supposed will amount to more than two thousand five hundred souls.

3. *Palæontographical Society.*—This Society was established in 1847, for the publication of works on British fossils, for the benefit of its members. A subscription of one guinea a year is required for membership, and the addition of names is solicited, as the amount of the publications per year depend on the income. The works thus far published are in 4to., and at the ordinary cost of similar publications could not be obtained at four times the amount which members actually pay. The engravings are in the highest style of the art, and the memoirs are all from authors of established reputation. The publications began in 1848, and are as follows :—

Monograph of the Crag Mollusca, or Descriptions of Shells from the middle and upper tertiary of the East of England; by S. V. Wood, F.G.S. Part I. Univalves; 208 pp., with 21 plates. Part II. Bivalves; 150 pp., with 12 plates.

Monograph of the Entomostraca of the Cretaceous Formation of England, by T. Rupert Jones, Esq.; 37 pp., with 7 plates.—A monograph of the Permian fossils of England, by Wm. King; xxxviii and 258 pp., with 28 plates.

Monograph of the Fossil Reptilia of the London Clay; Part I. Chelonia, by Professors Owen and Bell; 78 pp., with 28 plates. Part II. Crocodilia and Ophidia, by Prof. Owen; 68 pp. with 16 plates. Part III. Fossil Reptilia of the cretaceous formations, by Prof. Owen; 118 pp., with 37 plates.

The Eocene Mollusca, by Frederick E. Edwards. Part I. Cephalopoda; 58 pp., with 9 plates.

Monograph of British Fossil Corals, by H. Milne Edwards and Jules Haime. First Part: Corals of the Tertiary and Cretaceous Formations; lxxxvi and 72 pp., with 11 plates. Second Part: Corals of the Oolitic Formations; 75 pp., with 19 plates.

Mopograph of the Mollusca from the Great Oolite, chiefly from Minchinhamptin and the coast of Yorkshire; by J. Morris and John Lycett. Part I. Univalves; 130 pp., with 15 plates.

Monograph of British Oolitic and Liasic Brachiopoda, by Thomas Davidson; 64 pp., with 13 plates.

Monograph of the Fossil Lepadidæ or Pedunculated Cirripeds of Great Britain, by Chas. Darwin; 88 pp., with 5 plates.

Sir H. T. De la Beche is President of the Society. Persons wishing to subscribe, may address Searles Wood, Esq., Fortess Terrace, Kentish Town, England. Payment in advance is required.

4. *Dr. Krantz's Geological and Mineralogical Specimens.*—The writer, in company with the senior editor of this Journal, had an opportunity lately of examining the arrangements of Dr. Krantz's establishment for the sale of mineralogical and geological specimens, at Bonn on the Rhine. Dr. Krantz was induced to remove his collections from Berlin in consequence of the greater facilities in his present position, both for collecting and transmitting specimens. He has built a spacious house expressly for the accommodation of his business, and he merits the high reputation, which he already enjoys, for accuracy, integrity and zeal, in the department of science in which he is prepared to meet the wants of the scientific community. The highest confidence may be placed in both the names and localities of the species leaving his establishment. The geological series is peculiarly full and rich in American fossils from the older rocks, collected mostly under the personal supervision of Mr. Seamann, his highly intelligent voyageur who was in the United States in 1849—and who is now specially devoted to the geological department. It is rather singular, but we believe it is true, that it is easier now to get a good series of American fossils from Bonn, than to collect them in America, and certainly it may be done at less cost. Dr. Krantz's mineral cabinet, (his private one,) is one of the best in Europe, as it has been made up from the choicest selections of many years of active collection and exchange. It extends to over 6000 specimens and embraces fine examples of many of the rarest species. We cordially recommend Dr. Krantz's establishment to our friends as the best with which we are acquainted in Europe, for the sale and purchase of specimens. See his advertisement in detail in our advertising pages.

5. *Gold in Australia.*—Gold has been discovered, in the Blue Mountains of Australia, in the vicinity of Bathurst. It is said to be abundant, and many large masses have been found. One of eight pounds has been reported.

6. *Prize offered by the Royal Prussian Academy at Berlin.*—A prize of a hundred ducats is offered for the best work on the nature and mode of action, and resulting constitution, of hydraulic mortar, including the constitution of zeolites generally, but especially of those produced in the solidification of mortar.* The time allowed is till the 1st of March, 1854. The manuscript is to be either in German, Latin or French, and to include the name of the author. The prize will be adjudged "in conventu solemni Leibnitiano," which is held in the month of July, 1854.

OBITUARY.

Lorenz Oken, Professor of Natural History at the University of Zurich. He is well known for his views on the philosophy of nature, which are throughout profound; yet while partly exhibiting, as in his ideas on homology, a deep insight into the harmony of nature, even in ad-

* The following is from the announcement :—"Mortarii hydraulici quamquam natura jam magna ex parte perspecta est, continetur enim haud dubie formatione silicatorum ζεολιθωδῶν: restat tamen, ut chemica earum, quæ ex mortarii speciebus adhibitis oriuntur, conjunctionum ratio accuratius cognoscatur. Postulat igitur academia, ut universum hoc genus diligenter pertactetur, imprimis autem in earum, quæ ex mortario gignuntur, conjunctionum formationem methodis commodis inquiratur."

vance of discovery, they are partly mystical, and widely at variance with the system of existences around us.

ALEXANDER DE SALUZZO, President of the Academy of Sciences at Turin.

Mr. WILLIAM NICOL, the inventor of the single image prism of calcareous spar, known as Nicol's prism, and a frequent contributor to the Philosophical Journal. His age at death was 83 years.

BARON DE SILVESTRE, at Paris in his 89th year. He was one of the founders of the Philomathic Society, a member of the Academy of Sciences, and Perpetual Honorary Secretary of the Central National Society of Agriculture, of the list of whose members at its foundation, he was the sole survivor.

Dr. KÖNIG, for many years in charge of the Mineralogical Department in the British Museum. He died suddenly in August last.

IV. BIBLIOGRAPHY.

1. *United States Exploring Expedition during the years* 1838–1842, *under the command of Charles Wilkes, U. S. N.* vol. xi.—*Meterology*, by CHARLES WILKES, U. S. N., with 25 illustrations. Philadelphia, 1851.—This volume consists of a series of tables containing the meteorological observations made in the course of the cruise of the Expedition, preceded by an introductory chapter of 58 pages, treating of the general results, and illustrated by colored plates. On these plates, diagrams representing the track of the vessel, the changes in the temperature of the air on deck and at mast head, of the ocean, and of the barometric pressure, are given for the whole course of the cruise: and as the different lines are colored, the facts are brought out with unusual distinctness, and are convenient for comparison and study.

As the cruise occupied nearly four years, and extended over all the oceans of the globe except the Arctic, it is evident that the observations have no small interest. We have space to cite only the following from among the facts here registered. On Mauna Loa, at a height of 13,440 feet, the wind, for the most of the time passed at the summit, blew from the southwest, while it was from the north and northeast at Hilo, at the eastern foot of the mountains. All the gales experienced, seven in number, occurred at night, being most violent between the hours of 11 P. M. and 4 A. M.: only one of these gales was felt at Honolulu on Oahu to the west, while at Hilo none was experienced. Clouds were seldom seen above the height of 8000 feet, except during stormy weather; the vapor plane, or height at which the clouds usually remained, was about 5000 feet above the sea level. The sky instead of having the blackness spoken of by some travellers appeared of a beautiful blue. One of the most striking phenomena observed was the shadow of the mountain thrown at sunset on the eastern sky, looking like an immense dome bounded by an outline of a light amethystine tint, and deepening to a dark purple towards the center.

In the remarks on the barometric observations, it is observed that the results show a general depression within the tropics, a bulging in the temperate zone, and again a depression on advancing towards the Arctic and Antartic circles.

2. *Outlines of Chemistry for the use of Students;* by WM. GREGORY, M.D. First American from the second London edition, by J. M. SANDERS, M.D., LL.D. 12mo, pp. 614. Cincinnati. 1851: H. W. Derby & Co.—Dr. Gregory's outlines of organic chemistry, embracing the views of Liebig was extensively read, by chemists in this country, at the time of its publication, as the most compendious view of the condition of organic chemistry at that time accessible in the English tongue. That work is here reproduced by its author in an improved form and in connection with the inorganic chemistry now added, forms a very convenient and useful book, both for the student and teacher. Dr. Sanders's edition is a reprint from the London issue of 1847, very neatly done and with general accuracy. The peculiarity of Dr. Gregory's work compared with most chemical treatisés in our language, is the omission of all reference to the general powers of matter commonly called the 'imponderables.' The book is strictly what its title implies, and the student is supposed to derive his knowledge of physics as he does his mathematics and zoology entirely from other sources. Undoubtedly this is quite the correct course for the teacher of chemistry, and coincides, probably, with the sentiments of most lecturers on this subject. But unfortunately, and especially in America, it is rarely, indeed never, safe in a mixed class such as compose the medical schools in this country, to presume on the possession of such physical knowledge as is commonly imparted in the preliminary lectures of a chemical course. In fact, heat is a subject so closely connected with chemistry, and so dependent on a knowledge of molecular chemistry for its elucidation, that it is difficult to present either subject disconnected from the other. Nevertheless we are happy to have so good a book as Dr. Gregory's, accessible to chemical students in America, and have no doubt that it will be very useful and acceptable.

3. *Catalogue of Shells contained in the collection of Dr. John C. Jay.* Fourth edition, 4to. Dec., 1850.—The extensive collection of Dr. Jay, and his equally extensive conchological library, have for many years been well known to those who have made this science their special study; and they unitedly present advantages, which as yet are furnished by no public institution in our country.

The catalogue of a collection which M. Deshayes has declared "would, even in Europe, be considered one of the first rank," must possess interest to every student of natural history. The new and enlarged edition before us, is the largest printed Catalogue of recent shells ever published, enumerating about eleven thousand well marked varieties, and comprehending at least seven thousand well established species.

The value of the work however, is imperfectly indicated by its unassuming title, for it has far other merits than those of a mere catalogue. To every species is added not only its authorship and habitat, but also a complete synonymy, with references to all the good descriptions and figures extant. These references have all been carefully verified, which alone is a work of great labor, as they number about *eighteen thousand.* Every synonyme of any species (whether or not generally adopted) is found in its proper alphabetical place, followed by a reference to its received name. For instance, the student who is in doubt about *Helix*

radiata, Fer., turns to it at its proper alphabetical place in the genus *Helix*, and is there told that it is now known as *Bulimus detritus*, Müller. For this he searches in the genus *Bulimus*, and there finds it enumerated, with its complete synonymy, and reference to eleven authors who describe or figure it. The generic arrangement is essentially that of Lamarck with such modifications as the progress of science has rendered necessary. In the adoption of new genera proposed by later authors, the author has usually pursued a judicious course. Those genera which are founded upon sure, important, and identifiable characteristics, are for the most part received, while those founded upon trivial and uncertain points, indicative of groups of species merely, have been rejected. In the great family of Helicidæ, the species are so numerous that the temptation to adopt new generic distinctions is great, and a more advanced state of knowledge may perhaps justify such distinctions, but the author has wisely judged that our acquaintance with the soft parts of the widely varying species of this family is yet too limited to sustain even as subgenera the names proposed by Beck, Gray, Albers and others. An alphabetical index to the various genera, subgenera and synonyms mentioned in the catalogue greatly facilitates its use.

To amateur collectors the work may become specially useful for other purposes. By checking off upon it their own species, they become furnished with a catalogue of their own collections with little or no labor, and the printed sheets serve for very neat labels. The collection of Dr. Jay is arranged in the order of the catalogue, each specimen being numbered to correspond with it. Each species is placed upon a separate stand with a printed label, and all protected by glass. The whole affords an admirable model for the arrangement of natural history collections.

In spite of all the author's care, a few errors have crept in, but fewer than might have been expected in a work of so much detail. These we may hope will be corrected in the supplements which he may hereafter find it necessary to publish.

The work may be obtained from John Wiley, New York, J. B. Baillière, Paris, or from the author. J. H. R.

4. *A Synopsis of the Classification of the British Palæozoic Rocks;* by the Rev. ADAM SEDGWICK: *with a detailed Systematic Description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge;* by FREDERICK McCOY, Prof. Geol. and Min., Queen's Coll., Belfast. Part 2, Palæontology, 184 pp. 4to, with 11 lithographic plates.—We learn in the preface that this volume is the first fasciculus of Prof. McCoy's Descriptive Catalogue of the British Palæozoic Fossils, placed by Prof. Sedgwick in the Woodwardian Museum. This part is devoted to the Radiata and Articulata. The second which is promised before the close of the year, will include the Mollusca and Vertebrata, and complete the series. The whole number of plates when completed will be 23. This extensive work is in the hands of one of the ablest Palæontologists of Great Britain, and is well executed. The number of new species and new genera is large, and if our limits did not forbid, we should take pleasure in transferring the descriptions of the added genera to our pages.

Prof. Sedgwick states in the preface, that the natural groups in the British Palæozoic series which will be recognized and illustrated in the work are as follows :—1. Hypozoic rocks; 2. Cambrian rocks (1, lower, below the Bala limestone, 2, upper, above the Bala limestone); 3. Caradoc group, which is not represented in Scotland and North England, but often overlies the Cambrian rocks unconformably in Wales and Shropshire; 4. Upper Silurian, including the beds from the Wenlock shale to the Tilestone; 5. Old Red Sandstone or Devonian; 6. Carboniferous; 7. Permian groups, which end the Palæozoic series, and are immediately followed by the Trias or New Red Sandstone.

Prof. Sedgwick expresses his thanks to the syndics of the university press, for bearing the expense of the letter press of this part of the work, but adds that it has not been brought before the public without much anxiety, and great personal cost.

5. *Monographie des Polpiers Fossiles des Terrains Palæozoiques précédé d'un Tableau Général de la Classification des Polypes;* by MM. Milne Edwards and Jules Haime. (Extrait du tome V dei Archives du Muséum d'Histoire Naturelle.) 502 pp. 4to, with 20 plates. Paris, 1851.—This work embraces a general review of the classification of zoophytes, a synopsis of all known genera, together with an elaboration of a large amount of new material, involving the institution of many new genera and many changes in the limits of those before established. The results are of the highest value to zoological science, although it may perhaps be questioned whether the farther study of the subject will sustain all the subdivisions. Connected with the extensive work on British fossil corals by the same author, published by the Palæontographical Society, these labors form the most extensive contributions to this department of Palæontology hitherto made. Besides these, other memoirs on zoophytes have been issued by the same authors in recent numbers of the Annales des Sciences Naturelles: and we may say truly that all the publications of Prof. Edwards, bear the impress of profound research. The plates are exquisite specimens of art and faithful delineations of the species.

The work is of great importance to the American geologist, as it includes descriptions of many species from the Palæozoic rocks of this country collected by M. de Verneuil. It also embraces species from all parts of Europe and from Great Britain, studied from specimens sent to the author for description by prominent geologists or by visiting collections. The whole number of species is about four hundred.

6. *Elements of Analytical Geometry;* by Albert E. Church, A.M., Prof. Math., in the U. S. Military Academy, West Point. Author of Elements of the Differential and Integral Calculus. 300 pp. 8vo, New York, 1851. G. P. Putnam.—There are many attractions in the branch of mathematics to which this work is devoted, and a beauty, clearness and brevity in its reasoning which recommend it for class instruction. The author states in his preface that while endeavoring to preserve the true spirit of analysis as developed by Biot, in his admirable work on the subject, he has made such changes in the arrangement of the matter and the method of demonstration, as he believed would render the whole more attractive and easily acquired by any student possessing a knowledge of the elementary principles of algebra and geometry.

7. *The Terrestrial Air-breathing Molluscs of the United States and the adjacent Territories of North America;* described and illustrated by AMOS BINNEY, edited by AUGUSTUS A. GOULD, vol. 1, 360 pp., 8vo, with 16 plates; vol. 2, 362 pp.; (vol. 3 not yet issued, to be a volume of plates.) Boston, 1851. Little and Brown.—These volumes are of the highest honor to the lamented author, both as a contribution to science and an example of private munificence seldom equalled. Near ten thousand dollars will have been expended on the work when completed: and the whole edition—290 copies—is reserved for distribution. As the title implies, the work treats of molluscs, and not simply of shells. In addition to the description of species, it takes up the anatomical structure of molluscs of the different genera, and illustrates this department by plates of unusual finish and minute accuracy; it treats of the habits and faculties of species; of their geographical distribution, and foci of origin, and of the introduction of those of foreign countries into the United States. It corrects largely the synonymy of the science showing numerous cases in which the names of Say and other American writers have been overlooked even to the present time, by European authors. The beautiful dissections and anatomical drawings of vol. i, are by Dr. J. Leidy of Philadelphia, who has contributed a chapter on the special anatomy of these molluscs.

The death of Mr. Binney was a sad loss to American science. As one of the founders of the Boston Natural History Society, as a contributor to its Journal and Museum, as the possessor of an extensive scientific library which he was constantly enlarging by the frequent addition of rare works, as a man of elegant taste as well as science, and as a friend of all that was good, he was held in honorable and grateful esteem in Boston, and in other parts of our land. These his last labors, just now open to the world, will secure for his name the widest distinction.

At the death of Mr. Binney, the publication of this work was left by his will in charge of Dr. Augustus A. Gould of Boston, and it could not have fallen into better hands. Dr. Gould has brought out the work in excellent style and has added to it many notes of value, besides giving it his critical supervision.

8. *History of Propellers and Steam Navigation with Biographical Sketches of the early Inventors;* by ROBERT MACFARLANE, C.E. New York: Geo. P. Putnam. 12 mo. pp. 144.—The object of Mr. Macfarlane's book is to furnish means of reference to inventors for a comparison of their schemes with similar contrivances already known or proved valueless. Much waste of time and means may undoubtedly be thus saved by a meritorious class of men whose efforts are frequently expended in a wrong direction. The book is illustrated by figures of various forms of paddle wheels, among which are the several forms proposed by Mr. Ewbank as modifications of the usual rectangular and fixed paddles now in use.

An interesting sketch of the history of ocean steam navigation forms the concluding chapter of the book.

9. *The Geological Observer;* by Sir HENRY T. DE LA BECHE, C.B., F.R.S., &c., Director general of the Geological Survey of the United Kingdom. London: Longman, Brown, Green and Longmans. 1851. 8vo. pp. 846.—This is not a reprint of the author's well known vol-

ume, "How to Observe Geology," long since out of print, though to a certain extent founded on the former treatise. Its object is to afford a general view of the chief points of geological science, such as existing observations lead us to infer to be firmly established in order to show how the correctness of such observations may be tested; and to sketch the directions in which they may apparently be extended. The great experience of the author as a "geological observer," the very Nestor of British geologists, his critical and cautious mind, his freedom from the distorting and partial bias of favorite hypotheses, all render him pre-eminently the man to present a true account of the present achievements of geology, and to indicate the course of study and observation required to advance it.

10. *Elements of Geology, intended for the use of Students;* by SAMUEL ST. JOHN, Prof. Chem. and Geol., in Western Reserve College. New York: 1851. 334 pp. 12mo.—This small work contains a brief review of the principles of the science of Geology illustrated with numerous wood-cuts, &c., well calculated to interest and instruct the student. Chapter first, treats of the general features and constitution of the earth, and the causes of change, atmospheric, aqueous and igneous: chapter second, of the structure and position of rocks; chapter third of fossils; fourth, of unstratified rocks; fifth, of stratified primary (metamorphic) rocks; sixth, of the Palæozoic system; seventh, of the secondary system; eighth, the tertiary period; ninth, the quarternary period; tenth, theoretical geology; eleventh, practical geology; twelfth, history of geology; thirteenth, relation of geology to religion; fourteenth, geographical geology. The subdivisions of the palæozoic rocks and the local geology of the United States are mentioned under the last head, and sections are introduced illustrating the subject.

11. *The Microscopic Anatomy of the Human Body in Health and Disease, illustrated with numerous drawings in color;* by ARTHUR HILL HASSALL, M.B., with additions to the text and plates, and an introduction containing instructions in Microscopic Manipulation, by HENRY VANARSDALE, M.D. 2 vols. 8vo., 1 vol. text, 560 pp. and one of 79 plates. First American edition. 1851. New York: Pratt, Woodford & Co. The importance of microscopic research in the study of the human system, is now very generally appreciated by medical men. The work by Mr. Hassall is intended to present some of the results arrived at by various recent observers in microscopic anatomy, both by descriptions and full illustrations. The first volume contains an account of the structure of the various constituent parts, fluids and solids, of animals, and the second volume gives representations of the same in lithography. The seventy eight plates contain on an average six figures each, and in general are well executed. The last ten plates have been added by the American editor; they are among the best in the volume. We may add to the credit of American skill, that the plates of this edition are in general decidedly better than those of the London impression. The work opens with an introduction prepared for this edition, containing much information on microscopes and their accessory instruments for dissection, injection, and other purposes, and on the preparation and preservation of objects. The instruments of the more prominent makers abroad are remarked upon with discrimination, and also the recent

labors of Spencer and others in this country. The volume is therefore highly valuable as illustrating the modes of microscopic research as well as the results of investigations, and especially so to the student of medicine.

12. *The Microscopist, or a complete manual for the use of the Microscope, for Physicians, Students, and all lovers of Natural Science, with illustrations ;* by JOSEPH H. WYTHES, M.D., 191 pp. 12mo. Philadelphia, 1851, Lindsay & Blakiston. The recent multiplication of works on the microscope promises well for the future progress of American science. This little work is the third on the subject published in the country within the year past. It contains notices of different instruments, but is singularly deficient as an American work, in making no mention of the lenses of Canastota, which certainly are not surpassed in defining power by any abroad, and even take the lead of all others according to a report at the last meeting of the American Association. The volume contains descriptions of the microscope and its accompaniments, its modes of use, the methods of making preparations, and other information of importance to the young microscopist. We observe however, important deficiences and some errors ; among the latter, a mixture of alcohol and water is spoken of as the basis of the Gannal process of preservation, instead of acetate of alumina ; and the same objection is said to exist to the use of dilute alcohol, as to salt and water,—the objection to the latter, stated a few paragraphs above, being the development of a Confervoid vegetable.

13. *Report of the Special Committee in favor of a Geological Survey of California ;* submitted by Mr. RANDALL, April 24, 1851.—This well-prepared report sets forth in a just light the importance of a geological survey of California. We observe the statement with regard to the yield of the gold mines, that for the last three quarters of the year ending Dec. 31, 1850, the amount was not less than $70,000,000 ; and for the first quarter of 1851, at the rate of nearly one hundred millions of dollars per annum.

14. *Graptolithes de Bohême ;* par JOACHIM BARRANDE, (Extrait du Système Silurien du Centre de la Bohème.) 74 pp., 8vo with 4 plates. Prague, 1850.—Numerous species are described and well figured in this memoir. The genera to which they are referred are Graptolithus, *Linn.*, and Rastrites and Gladiolites of Barrande. Some of the figures remind us very much of the stems with their seriate cells in the Sertularia tribe of polyps.

15. *Prof. Owen, F.R.S., on Dinornis*, Part iv, containing the restoration of the Feet of that Genus and of Palapteryx, with a description of the Sternum in Palapteryx and Aptornis. 20 pp. 4to. with 4 plates ; from the Zool. Soc. Trans. vol. iv. Part 1. This important memoir is illustrated with excellent figures of the size of life.

16. *American Historical and Literary Curiosities, consisting of Fac-similes of original Documents relating to the events of the American Revolution, with a variety of Reliques, Antiquities, and Modern Autographs ;* collected and edited by J. JAY SMITH and J. F. WATSON. Fifth edition, with additions. N. Y. : G. P. Putnam. 1852. 4to, pp. with 56 plates.—This is mostly a work of curious literary and historical interest relating to American affairs. There is a fac-simile of a let-

ter from the celebrated Robert Fulton with a sketch of his first steam-boat. The letter is dated Sept. 26, 1802, from Paris, and in it he discusses the relative advantages of oars and paddles as a means of propelling a boat. Plate 28 gives a picture of John Fitch's steam-boat with his own description of the apparatus in the Columbian Magazine for December, 1786. A remarkable autograph letter follows under date of Dec. 25, 1790, in which he states that he gave his country this valuable invention on the 30th Aug., 1783, and had received no compensation. He adds, "another inducement which urges me to pursue this scheme is, to put it out of the power of future generations to make excuses for the present one—and if I should die in penury, want, wretchedness and rags, that my country may have no excuse, and that I may have the secret pleasure in the contemplation of receiving real pity from future generations." The work contains numerous titbits of scientific as well as general interest, mostly of a personal character.

16. *The Serpent Symbol, and the Worship of the Reciprocal Principles of Nature in America;* by E. G. SQUIER. 254 pp. 8vo. New York: 1851. G. P. Putnam. American Archæological Researches, No. 1.—Mr. Squier in his work on the Serpent Symbol, has brought his extensive Archæological knowledge to bear upon the history of primary religious ideas in the two continents. The work exhibits varied learning, and abounds in facts and suggestions that are of great interest. We are not prepared to admit however that they require or sustain the system of religious philosophy that pervades its pages. We should do the author however the justice to say that upon the main question, whether the resemblances in ideas between races is due to early connection or simply to identity of mental constitution, he observes that he would not express a preference for either hypothesis, much less decide between them; and if he has leaned to the latter, it has arisen from a desire to avoid the common error of attributing all coincidences and resemblances to intercommunication of races in periods more or less remote. Mr. Squier announces the following works of the Archæological series as prepared for publication, or as far advanced. 1. The Archæology and Ethnology of Central America. 2. The Mexican Calendar. 3. The Mythological System of the Ancient Mexicans. 4. The semi-civilized Nations of New Mexico.

Prof. J. W. BAILEY: Microscopical Examinations of Soundings, made by the U. S. Coast Survey off the Atlantic Coast of the United States.—From the Smithsonian Contributions to Knowledge. 16 pp. 4to, with 1 plate.—Also Microscopical Observations made in South Carolina, Georgia and Florida.—Smithsonian Contributions to Knowledge. 48 pp. 3 pl. We have to defer a farther notice of these interesting memoirs to a following number.

SAMUEL L. DANA: A Muck Manual for Farmers; 3d edition, revised and enlarged. 346 pp. 12mo. Lowel and Boston: 1851.

M. FARADAY: Experimental Researches in Electricity.—22nd series; Crystalline polarity of bismuth, antimony and arsenic, and on the magne-crystallic force.—23d series; On the supposed polarity of Diametric bodies.—24th to 27th series; On the possible relation of Gravity to Electricity.—On the magnetic and diamagnetic condition of bodies.—Magnetic conducting power.—Atmospheric magnetism.—From the Philosophical Transactions: No. 22, in the volume for 1849, 23, for 1850, 24–27, for 1851.

REPORT of the British Association for 1850. *London*, 1851.

MEMOIRS of the Geological Survey of the United Kingdom. Figures and descriptions illustrative of British Organic Remains, Decades I, II, III, 1849, 1850.

M. ADOLPH WURTZ: Memoire sur les Ammoniaques composées. (From vol. xi, of the "Memoires présentés par divers Savants à l'Academie des Sciences." 68 pp. 4to.

A. T. KUPFFER: Annales de l'Observatoire Physique Central de Russie, publiées par ordre de La Majesté l'Empereur Nicolas I, sous les auspices de Mr. Le Comte Wrotchenko, Ministre des Finances et Chef du Corps des Ingenieurs des Mines. Année, 1847. No. 1 and No. 2. pp. 844 and 394, with numerous plates of diagrams.

R. T. MAITLAND: Descriptio Systematica Animalium Belgii Septentrionalis, &c., by Prof. J van der Hoeven. Pars I. Animalia Radiata et Annulata. Large 8vo. xxxviii and 234 pp. Lugduni Bat. 1851. 1 *thal.* 26 *gr.*

FOERSTER: Monographie der Gattung Pezomachus. *Berlin*, 1851. Nicolai. 1½ *thal.*

HAEGHENS C. MARTIN and BERIGNY: Annuaire Meteorologique de la France pour 1851. 3d year. 1 vol. 8vo. 1851. 13 *fr.*

D. DUPUY: Histoire Naturelle des Mollusques terrestres et d'eau douce qui vivent en France. 4e fascicule. 4to. *Paris.* 10 *fr.*

A. D'ARCHIAC: Histoire des Progrès de la Geologie de 1834 à 1849, published by the Geological Society of France. Vol. 3, in 8vo. *Paris.*

VIOLETTE and ARCHAMBAULT: Dictionaire des analyses Chimiques, or alphabetical Repertory of the analyses of all bodies, native and artificial, from the origin of chemistry to the present time. Vol. 2, in 8vo. *Paris.* 8 *fr.*

FR. DE CASTELNAU: Expedition dans les parties centrales de l'Amerique du Sud, &c., under the order of Government, between the years 1843 and 1847. History of the Voyage. Vol. 3. 1 vol. in 8vo *Paris.* 7 *fr.* 50*c.*

A. BERTOLONI: Flora Italica, vol. 7, Fasc. 5, large 8vo. 27½ *gr.*

Dr. A. E. GRUBE: Die Familien der Anneliden m. Angabe ihrer Gattungen u. Arten. Large 8vo. iii, and 164 pp. 1 lithog. *Berlin*, 1850. Nicolai. 1 *thal.*

Dr. A. WAGNER: Beiträge zur Kenntniss der Säugethiere Amerika's. 3 abthl., arge 4to, 226 pp. and 7 lithog. 1851. 3⅙ *thal.*

FR. JUNGHUHN: Plantæ Junghuhnianæ. Enumeratio plantarum quas in insulis Java et Sumatra detexit. Fasc. 1, large 8vo, 106 pp. Lugduni Bat. ⅚ *thal.*

PROC. BOSTON SOC. NAT. HIST., 1851.—p. 17. On Mollusca of Massachusetts Bay; *W. Stimpson*, (continued.)—p. 18. New genus and species of American Cottoids, Triglopsis Thompsonii; *C. Girard.*—On Swamps along western rivers; *Desor.*—Rutile of Waterbury, Vt.; *A. A. Hayes.*—*Feb.* 19. p. 25. On American Holothuridæ; *Mr. Ayres*, (Psolus levigatus.)—p. 26. Identity of Nucula navicularis and N. thraciæformis; *W. Stimpson.*—On the teeth of a Hippopotamus; *J. Wyman.*—*March* 5. p. 30. On the organs of vision and nervous system of the embryo of Ascidia; *C. Girard.*—On the cause of the want of symmetry in the curves of the earth's strata as seen in the mountain chains of Europe and America; *Prof. Rogers.*—*March* 19. p. 35. Structure of spinal cord in Bats; *J. Wyman.*—Holothuridæ, (continued); *Mr. Ayres.*—p. 37. A new Etheostoma, E. Linsleyi; *H. R. Storer.*—p. 39. Analysis of Pitchstone of Isle Royale and of phosphate of lime of Hurdstown, N. J.; *C. T. Jackson.*—p. 41. On Dunes on the shores of the Upper American Lakes; *Desor.*—p. 42. Strobilophaga enucleator abundant in March in Vermont.—*April* 2. p. 46. New genus of Holothuria, Stereoderma; *Ayres.*—p. 47. Analysis of phosphate of lime of Crown Point; *C. T. Jackson.*—An Ascidian, Pelonia arenifera, in Massachusetts Bay; *Stimpson.*—p. 49. Parallelism of the Quarternary deposits of Europe and America; *Desor.*—*April* 16. p. 52. New genus of Holothuria, Bothryodactyla; *Ayres.*—p. 56. Reports of Curator.—p. 59. Election of Officers, J. C. Warren, M.D., President; C. T. Jackson and D. Humphreys Storer, Vice Presidents; J. Eliot Cabot, Corresponding Secretary; Nath. B. Shurtleff, Treasurer; C. K. Dillaway, Librarian.—p. 60. A new Holothurian; *Ayres.*—*May* 21. p. 63. New species of Psolus, P. granulatus; *Ayres.*

PROC. ACAD. NAT. SCI., PHILADELPHIA.—July, 1851. p. 235. Fungous disease of Cicada; *J. Leidy.*—p. 237. Fossil ruminant ungulates from Nebraska Terr., (Oreodon (near Merycoidodon) priscum, O. gracile, Cotylops speciosa); *J. Leidy.*—p. 239. Helminthological Contributions, No. 3. (N. g. Synplecta and Myzobdella and several species); *J. Leidy.*—p. 244. New birds of the family Laniadæ; *J. Cassin.*—p. 247. New species of Grapsoid Crustacea; *J. D. Dana.*

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(H No. 2)

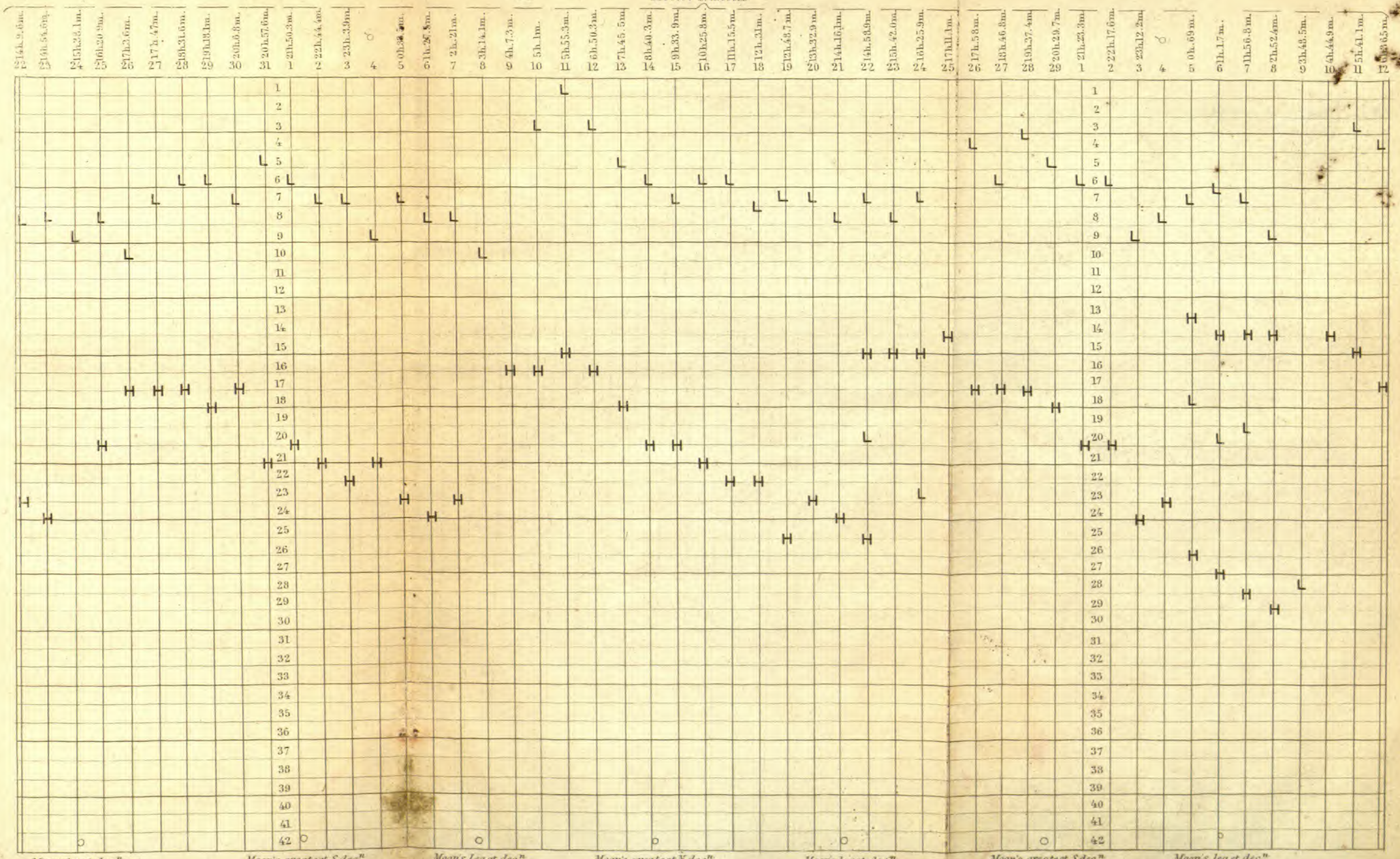
Plate 3

U.S. Coast Survey.

Tides at Cat Island Louisiana from the 22nd of January to the 12th of March 1848.

Rise and fall of tides from hourly observations.

Moon's Transits



Moon's least dec.n | Moon's greatest S.dec.n | Moon's least dec.n | Moon's greatest N.dec.n | Moon's least dec.n | Moon's greatest S.dec.n | Moon's least dec.n

The vertical lines represent one day

The space between the large horizontal lines represents 3 hours

" " " " small " " " 1 hour

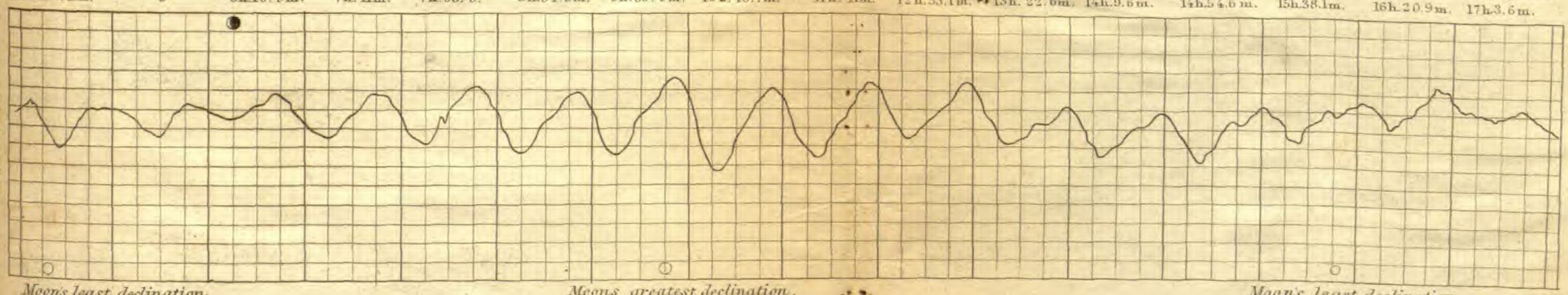
(H No. 3)

U.S. Coast Survey.

Tides at Cat Island Louisiana from the 11th. to the 26th. of January 1848.

Curves of rise and fall of tides from hourly observations.

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Moon's Transit. 4h.27.2m.	Moon's Transit. 0	Moon's Transit. 6h.10.9m.	Moon's Transit. 7h.41m.	Moon's Transit. 7h.58.8.	Moon's Transit. 8h.54.6m.	Moon's Transit. 9h.50.9m.	Moon's Transit. 10h.46.7m.	Moon's Transit. 11h.41m.	Moon's Transit. 12h.33.1m.	Moon's Transit. 13h.22.6m.	Moon's Transit. 14h.9.6m.	Moon's Transit. 14h.54.6m.	Moon's Transit. 15h.38.1m.	Moons Transit. 16h.20.9m.	Moon's Transit. 17h.3.6m.



The space between the large vertical lines represents one day.

" " " small " " " 6 hours.

" " " " horizontal " " half a foot.

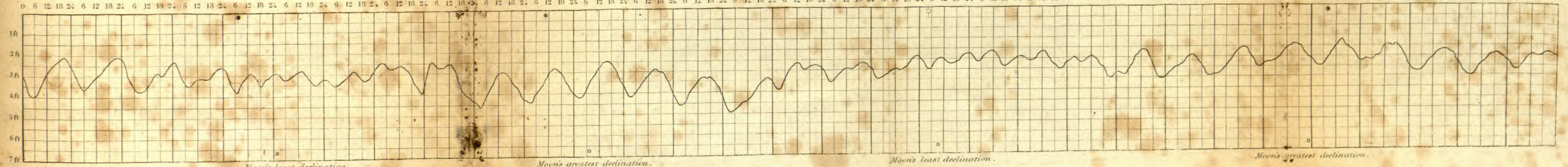
(H No. 3/4)

U.S. Coast Survey.

Tides at Cat Island Louisiana March 1848.

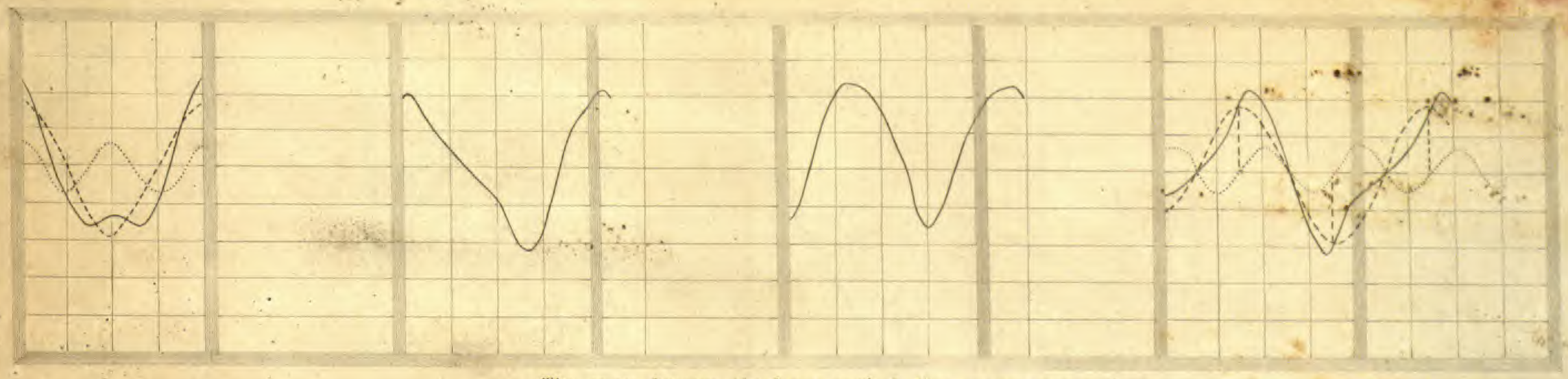
Curves of rise and fall of tides from hourly observations.

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd	23rd	24th	25th	26th	27th	28th	29th	30th	31st
Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.	Moon's Transit.
21h. 23. 3m.	22h. 17. 6m.	23h. 12. 2m.	○	0h. 6. 9m.	1h. 1. 7m.	1h. 56. 5m.	2h. 52. 4m.	3h. 48. 5m.	4h. 44. 9m.	5h. 41. 1m.	6h. 36. 6m.	7h. 30. 5m.	8h. 22. 4m.	9h. 12. 2m.	9h. 59. 7m.	10h. 45. 4m.	11h. 29. 6m.	12h. 12. 8m.	12h. 55. 7m.	13h. 38. 7m.	14h. 22. 3m.	15h. 6. 8m.	15h. 52. 7m.	16h. 40. 1m.	17h. 29. 0m.	18h. 19. 5m.	19h. 10. 5m.	20. 3. 1m.	20h. 56. 2m.	21h. 49. 6m.


0 6 12 18 24 6 12 18 24 6 12 18 24

(H No. 4/5)

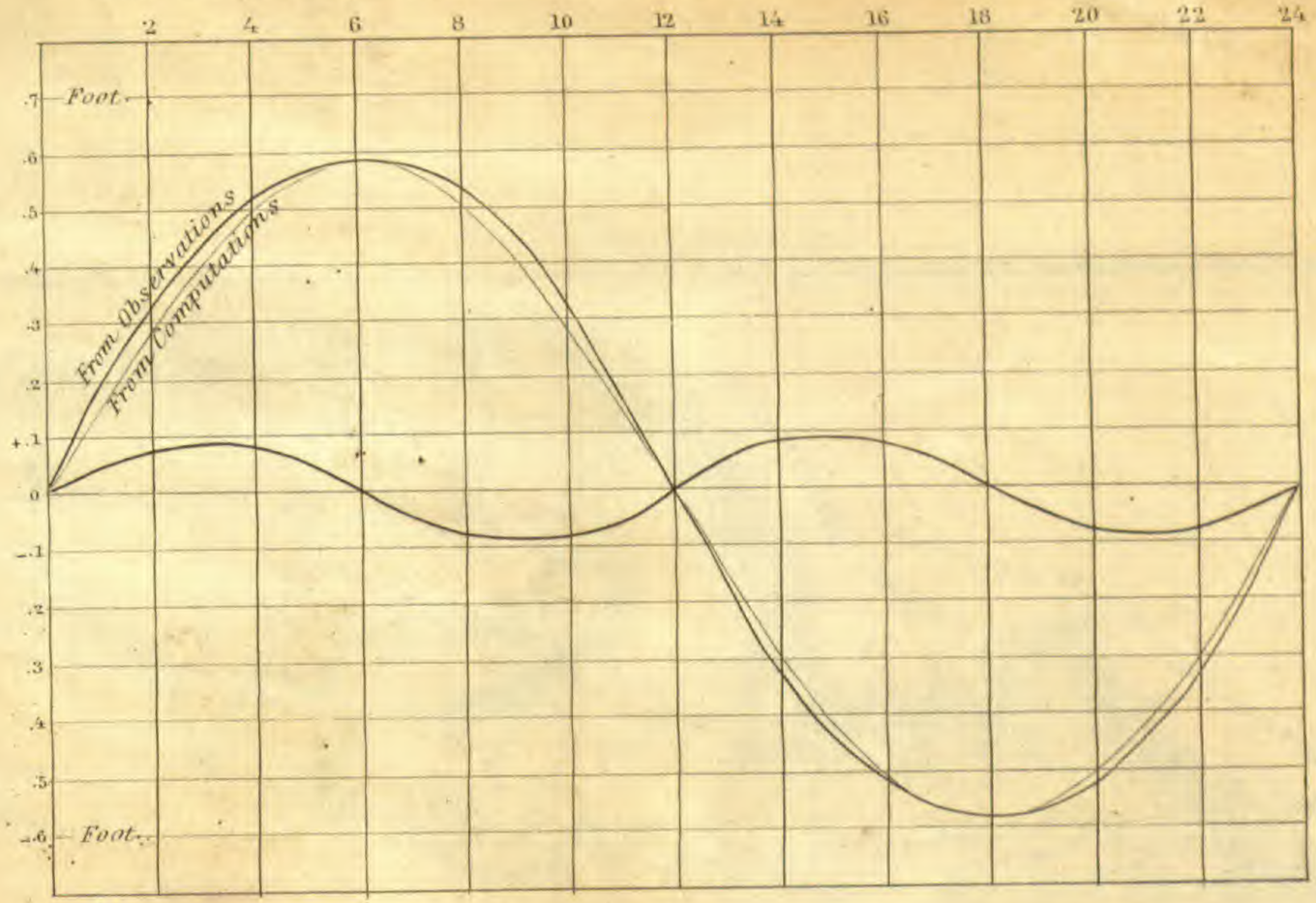
Forms of curves by interference for same values of C. & D. & E. for 0. 3. 6. & 9. hrs.



The space between the large vertical lines represents one day
" " " " small " " " 6 hours
" " " " " horizontal " " half a foot

(H No. 8)

Mean curves for Jan. Feb. and Mar. deduced from observations & computations.



The space between the vertical lines represents 2 hours.

" " " horizontal " " $\frac{1}{10}$ of a foot.

THE
SILURIAN BASIN
of
MIDDLE TENNESSEE
by
J.M. SAFFORD
Lebanon, Tenn.
1851.
Carboniferous
Siliceous Group.
Devonian
Black Slate.
Devonian and Up. Silurian.
Gray Limestone
Low. Silurian
Nashville Group.
Stones River Group.
Cedar Glades.
Barrens, etc.
Cumb. River.
Tenn. River.
Clarksville.
Gallatin.
Cumb. R.
Lebanon.
Nashville.
Stones River.
Frank.
Mur.
Wood.
Short Mts.
Smith.
Mc Min.
Coal Measures.
Cumberland Mountains.
Columbia.
Duck River.
Shelb.
Lew.
Man.
Mt P.
Buf R.
Elk River.
Winchester.
Tennessee River.
Per.
Sav.
Lith. of Richd H. Pease, Albany.
SECTION from A to B. through Winchester and Murfreesboro.
Cumb. R.
Stones R.
Duck R.
Elk R.
1000
500
0 ft.

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