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ERRATA TO VOLUME VI.—Page 251, l. 17 from top, for admissible, read inadmissible. Page 450, l. 6 from top, for Touer, read Toner. Page 478, l. 10 from foot, and 479, l. 16 from foot, for Princite, read Priceite.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

Art. I.—*Indian Mounds and Skulls in Michigan. Results of Explorations of* Mr. Henry Gillman. From the Sixth Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology, Harvard College, Prof. Jeffries Wyman, Curator.

A collection made by Mr. Henry Gillman from a mound on the Detroit River, Michigan, explored by him for the Museum, consists of human remains and various objects buried with the dead. The latter are of the common kinds, such as stone chisels, one of much beauty made of diorite and highly polished, a spear point, arrow points, stone pendants, a stone boring tool, beads and ornaments made of shell and copper, an implement made of an antler, a miniature vase of the size of a common thimble, and two large and perfect vases of the oval pattern and ornamented over the whole surface with cord marks.

One of the skulls, that of a fully adult person, is worthy of notice for its diminutive size, and for a remarkable extension of the lines for the attachment of the temporal muscle toward the top of the head. The average capacity of the Indian cranium, as given in the tables of Morton and Meigs, is eighty-four cubic inches, and the minimum observed by them sixty-nine cubic inches. That from the Detroit River mound measures only fifty-six cubic inches, or less than sixty-seven per cent of that of the average Indian. In ordinary skulls the ridges of the temporal muscles on the two sides of the head are separated by a space of from three to four inches, seldom less than two, while in the Detroit mound skull this space measures only three-quarters of an inch; and in this respect it presents about the same conditions as the skull of a chimpanzee. As the two other crania from the same mound offered no such peculiarities, the skull which has just been described must be considered simply as an extreme case of individual variation from the ordinary form. There are no signs of artificial deformity.

The single tibia accompanying this collection is somewhat flattened.

Mr. Gillman, under an appropriation made by the Trustees, has explored a series of mounds at the head of St. Clair River, and the collections made by him have been received and were accompanied with the following report:

The mounds situated at the head of the St. Clair River extend from south of Fort Gratiot for one and one-half miles northward, along the west shore of the river and of Lake Huron. It is altogether probable that they reach much farther, both northward and southward; but I have traced, examined and fully identified them for the distance mentioned. Similar works have been found on the opposite side of the river, in Canada. Isolated mounds in the interior also exist, an interesting example of which is seen on the west shore of the Black River (a tributary of the St. Clair), at a point about one and three-quarter miles southwest of Gratiot; the mound referred to having been exposed, some years ago, by the grading of a road through it, which, as usual, resulted in the loss of a large amount of valuable relics.

With few exceptions, all these mounds have a general resemblance, and bear the appearance of terrace-like embankments from ten to twenty and twenty-five feet in height; they are much longer than wide, and run nearly parallel to the general direction of the river and lake shore, which here does not vary much from north and south. They are mostly of the Drift formation, subsequently modified or added to by man for the various objects for which they were occupied, whether for the purposes of interment, habitation, or the manufacture of the rude implements connected with the daily life of that period; and, from the topographical features and the geographical position, they must have formed favorite places of retreat in war time.

Mound No. 1 is composed chiefly of sand and gravel, is about two hundred feet long by fifty feet wide, and is fifteen feet above the level of the river. It has rather abruptly-curving sides, and is built on a slope of the ridge, of Drift formation, on which the village of Gratiot stands.

A large excavation, made about fifty feet from the south end of the mound, disclosed the remains of four human bodies, at a depth of four feet from the surface. In an area of about ten feet square the four crania, with a portion of the accompanying bones, were taken out, but were in so decayed and tender a condition that, with the exception of a skull and a few of the long bones and vertebræ, they mostly fell to pieces. The bodies evidently were buried in a sitting posture. This was very apparent in one case, where the femora were found bent upon and above the tibiæ, the vertebræ, etc., resting upon these, while the skull lay on top, face downward, as though it had leaned forward originally, and had finally fallen over into that position. This cranium is that marked Skull No. 1, Mound No. 1; and the vertebræ and other bones thereto belonging may be found correspondingly marked. With these remains were associated fragments of pottery, the bones of fishes and birds, flint chips, and some stone implements of the rudest character. These last were mostly water-worn boulders, apparently used as hammers, and almost invariably shattered; and net sinkers, flattish, irregularly-elliptical stones, notched on the edges or partially grooved toward the center. It is interesting to notice that the tibiæ present the peculiar compression which I have found so marked a characteristic, and in such extreme degree in the tibiæ from the mounds on the Detroit River and the River Rouge, Michigan, establishing the fact that these, too, were platycnemic men.

After excavating to the depth of six feet, the coarse gravel of the Drift was encountered; but no further objects of interest being met with, the opening was extended in other directions to the westward, so as to open a lateral trench through the mound. This revealed several fireplaces, solid beds of black ashes from one foot to eighteen inches thick, with fragments of pottery and bone, flint chips, sinkers and broken hammers interspersed. The fireplaces were invariably at or near the surface of the mound, showing it to have been occupied for habitation subseqently to being used for burial purposes. Openings made at two points, about fifty feet from the north end of the mound, and also at a third point, half-way between these and the first excavation, added no facts of special interest. Two excavations were then made at twenty-five feet from the south end of the mound, showing fireplaces with the beds of black ashes two feet thick, and intermingled relics similar to those of the fireplaces already mentioned. Some of the fragments of pottery taken out here were uncommonly thick and coarse. Beneath were small pieces of the bones of man, but nothing further worthy of mention. The encroachment of the town on this mound, and on those to the west of it, prevented a more satisfactory examination.

The oldest residents (some born and brought up here) knew nothing of the character of the mound, though they remember that, many years ago, it was covered with a large forest growth.

Mound No. 2, which lies two hundred feet northwest of Mound No. 1, is over five hundred feet in length by from one hundred to one hundred and fifty feet wide; and of the general height of twelve feet above the level of the St. Clair River. It is bounded on the north by a small stream known as McNeil's Creek, which also runs southwardly all along its eastern slope, as well as a part of the south end of the mound. The ordinary observer will scarcely fail to notice that this mound is something more than the work of nature. Its sides have a graceful, gradual slope, with the exception of the side fronting the river, which is abrupt and terrace-like, even where not washed by the creek. Between the creek and the River St. Clair is some low lands with ponds, where are a few outlying mounds, small and of slight elevation. About two hundred feet of the south end of Mound No. 2 is clear of trees, except on the sides, and is covered with a smooth green turf. Excavations were made in a number of places, showing that this entire end of the mound was covered with a solid crust of black ashes from eighteen inches to two feet thick. So hard and solid was this crust that layers of it in large pieces several inches square and thick were taken up unbroken. Fragments of pottery showing a great variety of patterns, bones of animals, birds and fishes (some of the larger bones evidently smashed), flint flakes and chips, with stone implements, consisting principally of arrowheads, hammers and sinkers, were found intermixed with the ashes. The abundance of the sinkers and particularly of the broken hammers is a remarkable feature. Though such rude utensils, a selection from them is preserved, so as to give an idea of their character. I have not found elsewhere a similar condition of things, and believe that this end of the mound furnishes a nearer approach to the "refuse heaps" of the Atlantic coast than anything I have seen elsewhere on the shores of the Great Lakes. The absence of the shell deposit, however, makes a marked difference. I cannot find that those ancient inhabitants of this region had much recourse to shell-fish as an article of diet. The great abundance of fishes, and the ease with which they were captured, together with the multitude of land game, left them under no necessity to use the inferior fresh-water mussels for food.

From the large quantity of pottery fragments and broken hammers, together with the thick bed of ashes covering so wide an area of this mound, I incline to think that this must have been a point where the manufacture of their pottery was carried on to an unusual extent. The broken hammers may be accounted for by their having been fractured in pounding the grains used as food, and in cracking the bones of animals for the extraction of the marrow, indications of which are not wanting. The pottery found in both these mounds exhibits an unusual variety of patterns; though not a single utensil was taken out entire.

From want of time the investigation of the northern part of the mound, which is elevated at its center from two to three feet above the portion covered with the ash-bed, was confined to three points. No additional information was obtained, however, further than establishing for it a like origin with the other mounds.

All the northern portion of the mound and also the sides of the southern portion are covered with a large second growth of trees. These consist chiefly of White Pine (*Pinus strobus* L.), Scarlet Oak (*Quercus coccinea* Wang.), White Oak (*Q. alba* L.), and Basswood (*Tilia Americana* L.). The trunks of some of these trees have a diameter of from eighteen inches to two and one-half feet. A few decayed stumps of the original forest still remain. These average four feet in diameter.

Mound No. 3.—After the exploration of four other mounds, three lying northward, the fourth northwestward of Mound No. 2, which contributed no additional facts of particular value, other than their identity of origin with the rest of the group, attention was next directed to Mound No. 3, which proved to be the most interesting of the entire series. This mound is situated three-quarters of a mile northeastward of Mound No. 1. It is about five hundred feet in length, and in breadth varies from seventy to ninety feet; while its height above the surface of Lake Huron is twelve feet, or not more than five feet above the general level of the surrounding land. In general direction it corresponds to the other mounds, and there is little in its appearance to suggest its character or call the attention of any other than a practised eye.

A large excavation was made at its widest part, and about its center. Within two feet of the surface the bones belonging to a single body were unearthed, but in so tender a condition from age that they mostly crumbled to pieces. A few bones of birds and fishes were found with them. Some of the decayed roots of an oak tree stump, ten feet to the westward (and which will be further alluded to), had grown over and around these bones. The excavation was deepened, widened and carried farther to the eastward, opening a trench to the depth of six feet, but only small fragments of human bones resulted. The trench was then opened to the westward, toward the stump of the oak. When at the depth of five feet we came to a skull

(No. 1, Mound 3). Some of the bones first taken out overlay this, and decayed roots of the oak, as thick as a man's arm, stretched above it. The other bones belonging to the body appear dwarfish. It was buried with the head to the east, and the legs seem to have been drawn up, and not stretched out at full length. On removing these remains, we found, immediately underneath, a third body, placed so closely that the skull of the upper rested on that of the lower. At the head was a large quantity of the bones of birds and fishes, in a compact mass, as though once held in some wrapping or vessel which had decayed. These were pressed against the skulls, so that in some cases they adhered to them, and are, no doubt, the remains of the food placed with the dead. Such of the bones as could be removed are preserved, but a great portion crumbled to pieces. This body was buried with the head to the eastward. The roots of the oak tree had penetrated the bones in many cases, the long roots presenting some interesting examples of this, as the roots in their natural growth had first filled, then burst, the bones, so that in several instances the parts of the bone surrounded the now decayed root, imbedded in it. Such pieces as held together are forwarded. This tree, which evidently belonged to the second growth of timber, was, I think, a scarlet oak (*Quercus coccinea* Wang.), as the majority of the wood covering the southern half of the mound is of this species, together with the white pine. The decayed stump was two feet in diameter at the base, and at one foot above the ground divided into three trunks or main branches, each nine inches in diameter. These had been cut down, apparently, many years ago; and as between the first and two subsequent burials must have occurred, in all probability, some lapse of time, and the oak must have sprung up, reached its growth, been cut down, and its stump finally have decayed long afterward, some slight idea may be had as to the age of the first burial

The trench was now opened to the oak stump, when, from directly beneath it, skull No. 3 was taken out with the accompanying bones. Upon this skull lay a plate of mica, five by four inches, of a quadrilateral shape, the corners worn off. A pebble of water-worn coral rested upon the mica, as if to keep it in place. About the neck of the deceased a necklace of remarkable construction had apparently been hung. This uncommon ornament was composed of the teeth of the moose, finely perforated at the roots, alternating with wrought beads of copper of different lengths, and the perforated bones of birds stained a fine green color, the stain, in the few pieces preserved, being wonderfully fresh. Small portions of the cord to which they had been attached are still partially preserved and remain in the apertures of the copper beads. I suppose that the teeth alternated with the copper beads and the stained bones. One copper bead, which adheres by its oxidation to the perforated part of a tooth, sustains this conclusion. A rude stone axe, partially polished, lay beside these remains. All indicated that the dead had been peculiarly honored in his burial, and that he had been, perhaps, a noted personage.

Immediately to the northward of this body another was taken out, skull No. 4, with the remaining bones. These were under the edge of the oak stump, and, as well as the remains No. 3, were surrounded with masses of roots. Both bodies lay nearly side by side, and at the same vertical plane, five feet below the surface. As in the other cases, the bones of birds and fishes were found with the remains, but in small quantity.

The excavation was next carried southward, through the center of the mound, for a short distance; but no relics being met with other than a few fragments of broken hammers and flint chips, it was next opened in the opposite direction, northward, thus giving it the form of an irregular Latin cross. When a few feet to the northward of the remains last taken out (No. 4), we came upon skull No. 5, and following up the indications, recovered such of the remaining bones as could be preserved. With this body a flint arrowhead and some other rude stone implements were found: also a number of small shells, the species of which I have not determined, but which appear to have been used for some special purpose, perhaps as ornaments, as they were ground smooth at the base. About twelve of these were recovered, but there must have been many more originally, as a large number of them crumbled to dust, and also some of them might easily have been overlooked. A short distance westward of the last relics, skull No. 6 was taken out. The accompanying bones, as in the cases of the others, were very tender, and it was with extreme difficulty that any of them were recovered. The tibiæ exhibited the compression previously referred to in a marked degree. A large mass of fish bones lay in front of this body, which, like the previous remains (skull No. 5, etc.), was buried placed on its right side with the head toward the east, and the limbs drawn up closely to the chest. It is possible that they may have been buried in a sitting or crouched position, and have afterward fallen over; but I think they were buried as first mentioned. The absence of pottery with the interments in this mound is worthy of note, only two fragments being found in any part of the mound, and these apparently accidentally dropped.

Isolated excavations in different places throughout the extent of Mound No. 3, as also in a mound sixty feet to the west of it, contributed nothing specially entitled to record.

Mounds Nos. 4, 5, etc.—Mound No. 4 is eight hundred feet northeast of Mound No. 3. It is three hundred feet long by from thirty to fifty feet wide, and is a low sandy ridge with a series of nine conical elevations running along its length, and rising two or three feet above its general level, they having a diameter of from twenty-five to thirty feet.

Mound No. 5 is fifty feet to the westward of Mound No. 4, and is of a conical shape, forty feet in diameter, and nearly twelve feet above the level of Lake Huron, being between three and four feet higher than No. 4. Two other mounds of a smaller size but similar shape lie to the north of it.

From Nos. 4 and 5 were obtained a few stone implements, fragments of bones and pottery, with flint chips and the usual boulder-hammers, mostly fractured. Our limited time prevented as thorough an investigation of these mounds as their appearance certainly warrants. I believe the removal of those conical elevations in Mound No. 4 would be rewarded with interesting discoveries.

Other mounds to the northward and westward. belonging to the series, were also examined to the extent of confirming their claims to a like origin with those more thoroughly explored. A mound south of Mound No. 1 (the first investigated) contributed a few stone implements, which are forwarded. The large implement appears to me to resemble a spade, but may have been designed for some other use than that apparently indicated.

In conclusion, I would say that the facts observed fully prove this extensive group of mounds a rich field for more exhaustive research. And here I repeat the interesting fact that all the tibiæ unearthed invariably exhibited the compression or flattening characterizing platycnemic men. Unfortunately the bones generally crumbling to pieces prevented satisfactory measurements. But sufficient evidence was obtained (in connection with my discoveries in other parts of Michigan) to establish the point that this race, from the Detroit River to the St. Clair and Lake Huron, was marked with platycnemism to an extreme hitherto unobserved in any other part of this country, or perhaps any other country in the world. I cannot but believe, from what I have seen, that future investigation will extend the area in which this type of bone is predominant to the entire region of the Great Lakes, if not of the Great West; or, in other words, that at least our northern "mound-builders" will be found to have possessed this trait in the degree and to the extent denoted. I am unable to say whether this peculiarity prevails in our modern Indian or not.

With the exception of the rude stone hammers and the sinkers, the number of perfect stone implements seems to me unusually small throughout this entire series of mounds. The question arises: Had this people the habit of sometimes breaking the stone implements cast into the burial mounds. Or were broken ones selected for this purpose as being of little other use?

ART. II.—*Silt Analyses of Mississippi Soils and Subsoils;* by EUGENE W. HILGARD, State Geologist of Mississippi.

THE results here communicated are the first-fruits of an investigation on the physical constituents of soils and clays, undertaken with the aid of the "churn elutriator" for silt analysis, described in another paper. While far from being as complete or satisfactory as I could desire, there is much that is suggestive of the direction to be pursued in the farther prosecution of the research, and of the importance of the results to be attained. The necessary interruption of the work on my part, for some time to come, may serve as an additional apology for an otherwise somewhat premature publication.

The materials of which the silt analyses are here given were chosen as typical representatives of the more important varieties of soils in the State of Mississippi. For reasons repeatedly explained, I have, in most cases, preferred to deal with the subsoil instead of the soil itself, whose organic ingredients materially interfere with the operations of analysis, as well as with the interpretation of the results. The general differences between the soil and subsoil, in ordinary cases, are well understood; and for general research and comparison, the latter is much more available. I have nevertheless, in one case, analyzed the soil and subsoil (206 and 209 of the table) for comparison; the differences falling, as will be seen, just where they would be expected. The deficiency in the summing up of the "*soil*" arises mainly, of course, from the dissolution and loss of vegetable matter.

As a standard for comparison and reference, I place first in the table a very pure, highly plastic pipe-clay; probably as free from foreign admixtures as a sedimentary clay can well be, the sediments being exclusively white quartz grains, sharp and angular. It resembles kaolin, and is probably directly derived from the Carboniferous fire-clays.*

* Miss. Rep., 1860, p. 34 and ff.

Silt Analyses of Mississippi Soils and Subsoils.

				UPLAND.											MISSISSIPPI BOTTOM.							
				DRIFT.	YELLOW LOAM.							TERTIARY.			CHAMPLAIN.		MODERN.					
					SANDY.			LOAM.				CLAY.			SWAMP	RIVER.	RIVER DEPOSIT.			DELTA.		
				238	248	165	206	209	397	219	173	230	246	196	390	237	365	377	395			
	Designation of Materials.	Diameter. (Millimeters.)	Velocity (Hydr. V.). Millimeters per Second.	White Pipeclay. Tishomingo Co.	Tallahoma Subsoil. Jasper Co.	Lt. Flatwoods Soil. Chickasaw Co.	Pine Hill Soil. Smith Co.	Pine Hill Subsoil. Smith Co.	Oxford Subsoil. Lafayette Co.	Table Land Subsoil. Benton Co.	Prairie Subsoil. Monroe Co.	Hy. Flatwoods Soil. Pontotoc Co.	Red Hills Subsoil. Attala Co.	Hog Wallow Subsoil. Jasper Co.	Buckshot Soil. Issaquena Co.	Loess. Claiborne Co.	Tallahatchie Soil. Panola Co.	Frontland Subsoil. Sunflower Co.	Dogwood Ridge Soil. Coahoma Co.	Southwest Pass. Plaquemine Par.	Southwest Mudlump. Plaquemine Par.	Velocity (MM.).
1	Coarse Grits,	1·0 to 3·0			6·94	2·90	0·36	0·36		} 0·23	} 2·10	0·33	} 1·97	0·83	0·09	} 0·24	} 0·09					
2	Fine "	0·5 to 1·0			17·65	6·96	2·98	0·83				0·35		1·19	0·05							
3	Coarse Sand,	80 to 90 / 180	64		18·81	2·81	6·62	6·21		1·47			0·72	1·96		0·37	0·04		0·15			64
4	Medium "	50 —55 "	32	} 0·06	10·16	4·41	7·75	3·38	} 0·79	2·33	} 0·62		2·32	1·64	0·36	0·61	0·05	} 0·32		} 0·18	} 0·10	32
5	Fine "	25 —30 "	16		2·66	3·13	3·01	3·85		1·17			2·09	0·88		0·93	0·21	2·97		0·47	5·02	16
6	Finest "	20 —22 "	8	0·08	1·66	2·02	1·59	1·49	0·18	0·78	0·20	0·23	0·70	0·26	0·31	1·65	1·30	2·41	3·74	7·03	3·68	8
7	Dust "	12 —14 "	4	0·02	1·02	2·23	1·19	0·64	0·78	0·76	1·26	0·18	1·29	0·19	0·27	1·95	2·68	16·90	21·49	12·38	5·34	4
8	Coarsest Silt	8 — 9 "	2	0·04	0·88	5·06	3·56	2·63	3·56	9·79	2·92	1·61	1·81	2·49	1·56	14·25	9·38	19·79	21·83	13·27	10·09	2
9	Coarse "	6 — 7 "	1	0·08	1·96	9·67	6·50	5·40	13·12	7·26	7·36	2·66	3·60	3·67	2·23	16·20	9·88	13·90	14·01	15·87	5·58	1
10	Medium "	4 — 5 "	0·5	0·08	7·89	14·18	13·97	7·77	16·64	13·14	8·81	9·13	2·73	5·39	3·68	20·08	20·37	4·27	9·93	8·25	9·54	0 5
11	Fine "	2·5— 3 "	0·25	2·00	8·40	22·03	14·20	16·65	27·28	15·07	7·85	26·64	13·30	10·31	8·97	5·59	19·79	1·89	9·58	7·26	8·01	.0·25
12	Finest "	0·1— 2 "	<0·25	21·15	15·53	15·62	29·36	37·75	18·87	26·50	35·22	32·35	25·33	24·18	38·19	33·38	25·30	30·08	8·65	19·67	34·46	<0·25
13	Clay,	?	<0·0023	74·65	8·63	7·86	4·58	10·70	17·23	19·19	33·16	25·48	40·25	47·03	44·30	2·51	9·64	5·51	10·35	12·20	18·18	?
				98·16	99·28	98·68	95·67	97·77	98·35	97·65	99·50	97·87	96·11	100·00	100·01	97·74	98·73	98·04	99·72	96·58	100·00	
	Compactness (resistance to tillage),			97·80	32·56	45·33	48·14	45·10	63·38	60·82	69·77	84·47	78·88	81·52	89·46	41·48	54·63	37·48	28·57	39·13	60·65	
	Porosity,			0·36	59·55	40·40	37·89	47·13	20·23	26·04	17·04	6·40	39·18	10·12	4·87	38·44	23·63	58·25	61·50	49·20	28·81	
	Hygroscopic moisture (+7° to +21),			9·09	1·80	3·36	2·48	7·69	8·79	7·21	11·35	9·33	18·60	14·48	14·31	4·18	6·12	5·68	3·95			
	Ferric oxide,			0·13	1·10	(1·45)	1·25	4·15	2·53	5·11	5·42	(5·90)	10·50	4·00	(5·82)	3·27	2·58	2·31	2·69			

Of the "Upland" soils in the foregoing table, Nos. 248, 206, 209, 397, 219 and 173, are properly of the "Yellow Loam" age, *i. e.*, of the end of the Drift period;* while 165 is one of the two chief varieties of soils occurring in the "Flat Woods," a level area bordering on the Cretaceous, and mostly characterized by the occurrence of the Lower Tertiary clays near the surface. The *light* soil (165) occurs in irregular strips and patches; it is very easily tilled at all times; all rain water is promptly absorbed; but it is too "open," droughty, and does not hold manure at all.

No. 248 forms a stratum three feet thick, on the ridges east of Tallahoma Creek, Jasper County, Miss. By its disintegration, it forms a deep and extremely sandy soil, which is injured by high winds carrying away its finer parts. It has, however, yielded good crops of corn and cotton for fifteen years without manure, though liable to injury from drought.—Nos. 206 and 209 are typical of the "Pine Hill" region of South Mississippi, the home of the long-leaved pine. The soil is very "light" and easily tilled, but not nearly as "open" as the preceding two. It is materially improved by the admixture of the subsoil, No. 209; which enables it to hold manure, being what would be termed a "sandy loam."

Nos. 397 and 219 are typical of the cotton uplands of Western Mississippi and Tennessee; 219 being of the first quality; 397 a second rate soil. Their prominent characteristic is an excessive and most distressing proneness to denudation or "washing," in consequence of a want of perviousness, together with the property of promptly swelling up, on contact with water, into a loosely gelatinous condition, in which they readily diffuse in water. From the same cause, the frequent alternations of freezes and thaws in the winters of their latitude of occurrence, are even more disastrous, and cause a frequent freezing-out of winter grain, that at first sight seems very surprising. The effects of denudation on these soils are but too obvious even to the passer-by, are difficult to check, and are fast assuming the proportions of a public calamity.

These soils are easily tilled when in the proper condition, but if ploughed too wet are severely injured, hard clods remaining throughout the season. There readily forms on their surface a very hard crust (they "bake"), so that the surface requires stirring after every rain.

No. 173 is the subsoil of the Cretaceous prairies of Northeastern Mississippi, forming a stratum three to seven feet thick, overlying the Cretaceous rock. Although, in the wet condition, it is accounted a "heavy clay" soil, it possesses the peculiarity of "slaking" on drying, instead of forming a hard crust—unless,

* Miss. Rep., 1860, p. 197.

indeed, the drying process be exceedingly slow. It is not, therefore, as difficult to cultivate as would be supposed from the sum of its fine ingredients. Nor is it nearly as much subject to denudation as the two preceding soils, the mass formed by its contact with water being too tough and coherent to be readily moved by flowing water. But being very little pervious, it is liable to injury in wet seasons; while in dry ones, the cracks formed by the contraction of the subsoil prove disastrous.

No. 230 is the soil prevalent in the Flatwoods (see above), and is the direct result of the disintegration of the old Tertiary clays. It is a very heavy, intractable soil, yielding good crops only in very favorable years, as it is exceedingly liable to injury both from wet and dry seasons, and can be tilled only within a very limited range of condition as to moisture. Water will stagnate on it for weeks, and a late, wet spring will, sometimes, altogether prevent the pitching of crops. But it is not at all liable to denudation.

No. 246 is likewise the direct result of the disintegration of (highly ferruginous) Tertiary clays. Notwithstanding its high percentage of "clay," it is more easily tilled than the preceding one, although acquiring a stony hardness when dried slowly. The fact that among its 40·25 per cent of "clay" there are 10·6 of ferric oxide, and that it contains ·8 per cent of lime, explains both its easier tillage and greater thriftiness, as compared with the preceding. It is a pretty "safe" soil, and quite productive; not at all subject to denudation.

No. 196 is the extreme of a clay soil, so as to be almost unfit for tillage, and directly available for the potter's lathe. It bears, nevertheless, a pretty good growth of timber, chiefly pine. Its popular name is derived from the peculiar aspect assumed by its surface, when after a drought which has caused fissures (as much as an inch wide) to be formed, a rain causes the edges first to crumble off into the open cracks, and then swell; which, with the subsequent swelling of the mass itself, compels it to bulge up. The result is a hillocky surface, which is popularly likened to "hog wallows." The soil is, at present, practically worthless.

The next, No. 390, is very similar in its (ostensible) physical composition to the preceding. Yet while the "hog-wallow" soil is among the most worthless of the soils of Mississippi, this, the celebrated "buckshot" soil of the Mississippi bottom, is among the most valuable. True, the chemical composition of the buckshot soil is greatly superior to that of the other yet it could not rank as highly as it does, as a cotton soil especially, but for the fact that (in common with the prairie soil, 173, above described) it possesses the property of crumbling or "slaking" by rapid drying; so that, even when it has been ploughed too wet, on drying each clod resolves itself into a pile of loose crumbs, which have given rise to the popular name of "buckshot." Notwithstanding its clayeyness, it is therefore a very "safe" soil, and highly esteemed for its thriftiness.

Alongside of this soil, which represents the cypress swamp deposits of the "Port Hudson" epoch of the Champlain period of depression, I give the composition of the "Loess" of the Lower Mississippi; a deposit evidently formed in a shallow, broad fresh-water estuary possessing a slight flow, during the time of more rapid depression of this portion of the continent. It forms a soil very easily tilled, somewhat too open and droughty, but fairly productive, and practically exempt from denudation.*

It is interesting to compare this ancient deposit with those now formed, under somewhat analogous circumstances, by the sluggish "bayous" traversing the bottom of the great river. Compare No. 237 with 377, a "Frontland" soil from a plantation on Indian bayou in Sunflower County, and we find the physical constituents almost identical. No. 395 is from a point near the main river, on Gov. Alcorn's plantation in Coahoma County; it has evidently been deposited by a more rapid current, as it contains more of the coarser ingredients, to which there adhered a sufficiency of clay to render the soil retentive, though so porous that water will not stand on it for a moment. It is very easily tilled, and from its great depth is very productive.

I subjoin, for farther comparison, the analysis of a specimen of river deposit, taken in the shallow water of the Southwest Pass of the Mississippi River, three miles below the Head of the Passes, at extreme low water. Here, again, the sediments of 1, 2, 4^{mm} form the prominent landmarks, as in the two other river deposit soils; in which the clay and finest silts seem to be the chief variables.

Having thus established, presumably, the normal composition of the river alluvium proper, I add, for farther comparison, the analysis of material from a stratified mudlump cone, which greatly resembles in aspect the river deposit. The point to be determined is whether this cone represents an upheaved mass of river deposit, or the mud ejected from a mudlump crater†—an eruption cone. The result seems to point to the latter as the more probable origin of the mass, as it presents but little similarity to the recognized river deposits, in the proportions of its sediments.

* Miss. Rep., 1860, p. 314.

† See my paper on the Geology of the Delta, and the Mudlumps of the Passes of the Mississippi, Am. Jour. Sci., April, May and June, 1871.

In discussing the results of these analyses, I first recall to mind the practical object primarily intended to be subserved by them, viz: to convey to any intelligent mind, anywhere in the world, a definite idea of the physical qualities of the soil; of its tillability, so to speak; of its behavior in wet and dry seasons; its liability to washing, etc. If the data given in the table do not at present convey such definite knowledge to the minds of this audience, it is because the molecular properties of the several sediments are not yet fully known, nor generally understood. But there can be little difficulty in the empirical determination of these factors, once for all, so far as they refer to the pulverulent minerals, whose physical properties are sensibly dependent upon the size of the particles alone; the differences of specific gravity, etc., being ordinarily too slight to influence materially their modifying influence upon the clay, or upon each other. To this rule mica and bog ore form, probably, the only practically important exceptions.

As regards the modifying effect upon the extreme plastic properties of the clay, the pulverulent ingredients obviously divide into two chief classes, viz:

1. The coarse portion, which increases the "lightness" and porosity of the soil, sensibly in proportion to its percentage.

2. The fine portion, which, while modifying the plastic properties of the clay, yet renders the soil heavier in tillage than would be the case if it were absent, and the clay adherent to the coarse particles alone.

Soils consisting mainly of very fine siliceous silt, with only a small percentage of clay, are among the very heaviest, working "like putty," clogging the plough when in the least degree too wet, and in drying, caking into clods of "hardpan."

Such being the case, it would seem that between the coarse part which lightens soils, and the fine silts which, like clay, render them heavier, there must be a neutral point—a degree of fineness which will not sensibly influence either the porosity or the compactness of the soil. Odd as this conclusion appears, it seems nevertheless to be borne out by experience.

In fingering the coarser silts, it at once becomes obvious that nothing above 1^{mm} hydr. value can tend to render a soil heavier; while it is equally manifest that the impalpable particles belonging to the velocity of $0{\cdot}25^{mm}$ cannot tend to lighten. In searching tentatively, by the summation of groups of physical ingredients, for numbers that would satisfactorily express the estimated relative resistances to tillage of the soil analyzed, I found that such numbers would result from a summation of the three items lowest in the column, viz: the silts of 0·25, $<0{\cdot}25$, and clay. These are given under the head of "Compactness" or "Resistance to Tillage."

Similarly, numbers satisfactorily expressing the relative "Openness" result from the summation of the coarser ingredients, down to 1^{mm} inclusive. These numbers are given opposite to the heading "Porosity."

But either series becomes quite unsatisfactory, so soon as the silt corresponding to $0{\cdot}5^{mm}$ is added either way; except, of course, where its percentage is too small to influence either sum very seriously.

Of course these can only be approximations, it being especially obvious that sand of 64 and 32^{mm} must exert a much greater influence toward rendering a soil "open," than silts of 1 or 2^{mm}; which are, nevertheless, accounted for as equal in effect, in the above summation. Yet even here there are counterbalancing considerations, which in a measure explain the comparatively close approximation to the result of experience. Chief amongst these is, doubtless, the circumstance that the finer materials, when damp and stirred up (as they are in the cultivated soil), will occupy a much greater bulk than equal weights of coarse sand; being in what is technically termed a "woolly" condition of looseness. It is therefore quite intelligible that, within certain limits, "coarse silt" should exert a "lightening" influence equal to that of "coarse sand," which is apt to pack quite closely.

It may be asked, What would be the character of a soil consisting exclusively of the silt of $0{\cdot}5^{mm}$, claimed to be sensibly neutral in its effect on the compactness and porosity of soils? I reply that, judging from the small quantities of material at my command, such soil would offer an extremely slight resistance to tillage, and that such resistance would be increased by the addition of either clay or sand, in proportion to the amounts added.

The case, however, can hardly occur in nature. The difficulties encountered in separating the several materials in accordance with their hydraulic values, even by the aid of apparatus especially constructed for the purpose, forcibly suggests that it is scarcely possible that such conditions should ever be realized in nature: the tendency to coalescence of particles necessarily causing all sedimentary deposits to consist of molecular aggregates (at least so far as the finer portions are concerned), instead of simple granules. These aggregates will rarely, if ever, consist of particles of equal hydraulic value, the natural tendency being for small particles to fill up the interstices left between larger ones, which cannot attain close contact between themselves alone.* Moreover, in view of this inevitable formation

* There is a sensible difference, in this respect, between materials much rounded and water-worn, and those whose grains are still "sharp." The latter are much more difficult to separate in the churn elutriator, and re-coalesce most pertinaciously.

of aggregates, the molecular properties of a clay or subsoil will never correspond exactly to the mean resulting from a mere consideration of the molecular coefficients of each one, multiplied into its percentage. How far this difference extends, is a question involving a previous investigation of those coefficients.

Among the latter, that of absorption of aqueous vapor is of no mean importance, since it determines, in a great measure, the resistance of the soil to drought. As heretofore stated,* I find that at temperatures between +7° and +21°, the amount of aqueous vapor absorbed by a thin layer of a clay, or soil not unusually *rich in humus*, in a saturated atmosphere, is sensibly constant; the variations being within the limits of errors of observation, and indiscriminately either way. A glance at the data given in the table, opposite the heading "hygroscopic moisture," shows that while in general, as is well known, clay soils are more absorbent than sandy ones, yet there exists no direct numerical relation between the amount of clay present and the absorbing power. Not only is that of the typical white pipe-clay (No. 238) scarcely greater than that of an ordinary loam subsoil (Nos. 397 and 219), but it is not half as great as that of the clay soil 246 (with 40 per cent of "clay"), which in its turn has a higher absorptive coefficient than 196 (with 47 per cent of clay). Finally, 230, with 25·5 per cent of clay, is more than equal in hygroscopic power to the pipe-clay with 75 per cent.

Evidently, the hygroscopic coefficient is largely controlled by the presence, with the clay, of the powdery ingredients which determine its looseness of texture, so to speak; moreover, the finer silts themselves possess a considerable absorbing power. Again, the presence of hydrated ferric oxide materially influences this power; so much so that no general conclusion concerning the hygroscopic effect of "clay" can be reached, unless the amount of iron present be taken into account. I am unable, as yet, to furnish this datum for all the soils on the table, save as regards, for most of them, the percentage in the original substance. That the hydro-ferric oxide accumulates mainly in the "clay" obtained in silt analysis, I have already stated; and hence the percentages given at the bottom of the table may measurably serve to form an estimate of its influence on the hygroscopic properties. In some cases, however, the ferric oxide obtained in analysis was almost altogether present in the shape of bog-ore grains; these are placed in parentheses, it being obvious that the "white" soils, to which these determinations belong, do not contain exceeding 0·5 per cent of the oxide in the finely-divided, hygroscopically effective con-

* Proc. Am. Assoc. Adv. Science, Dubuque meeting, 1872, p. 73.

dition. In the coarse sandy soil 248, the iron mainly incrusts the sand grains; and in Nos. 165, 206 and 390, the presence of humus, in sensible quantities, influences the coefficient. In the rest, the amount of humus is insignificant, and the influence of the finely divided hydro-ferric oxide is especially noticeable when we compare Nos. 209 and 397 with each other; and also Nos. 230 and 196 with 246. The clay obtained in the silt analysis of No. 219 contains, according to Mr. Loughridge's determination,* 18·76 per cent of ferric oxide, as compared with 5·60 in the original substance; its absorptive coefficient was 20·0, as compared with 7·21 in the original. How much of this increase of hygroscopic power was due to the concentration of the clay alone, we can at present but conjecture; but if we may judge by the absorptive power of the pipe-clay 238, the increase must be largely attributed to the hydro-ferric oxide.

The influence of "humus" on the hygroscopic power is known to be very great; so also is that of the soils' porosity and resistance to tillage. Unfortunately, the very indefinite character of "humus" renders it extremely difficult to determine quantitatively its action, and take it into account.

The questions remaining to be determined in connection with this whole subject are so numerous, and so little explored as yet, that their full elucidation might well form the work of a lifetime.

Art. III.—*On the Distribution of Soil Ingredients among the Sediments obtained in Silt Analysis*; by R. H. Loughridge, Assistant State Geologist of Mississippi.

In connection with the separation of soils into sediments of definite hydraulic value, as accomplished by Dr. Hilgard's churn elutriator, an interesting question arises as to the chemical composition of the sediments obtained.

It is evident from his results that, in the soils treated, all of the important soil ingredients are contained in the finer sediments, there being visibly nothing but quartz sand of different diameters remaining in the coarser ones.

Does then the "clay" contain them all, or are they more or less distributed among the several proximate sediments?

In the investigation of this question, use was made of the same yellow loam upland subsoil, from Benton Co., Miss., that formed the subject of my experiments on "Strength of Acid and Time of Digestion." Great care was taken to obtain a

* See the succeeding paper.

complete and pure sedimentation, distilled water being used; and the analyses were made, according to our usual method, after five days' digestion in acid of strength 1·115.

In the following table of results the percentages are given, first with reference to the absolute amount of each sediment itself; then with reference to the entire amount of soil taken for elutriation. In the last column a summation is made of each ingredient for comparison with a previous analysis of the soil, which is placed alongside.

Hydraulic Value, . . .	CLAY.		<0·25 mm.		0·25 mm.		0·5 mm.		1·0 mm.		Other Sediments	Total in Sediments	Original Soil.
Per Cent. in Soil, . . .	21·64.		23·56		12·54		13·67		13·11				
	A	B	A	B	A	B	A	B	A	B			
Insoluble residue,	15·96	4·35	73·17	17·29	87·96	11·03	94·13	12·72	96·52	12·74	13.76	71·89	70·53
Soluble silica,	33·10	7·17	9·95	2·34	4·27	·53	2·35	·32				10·36	12·30
Potash,	1·47	·32	·53	·12	·29	·04	·12	·01		0·36 (Potash to Volatile matter)		·49	·63
Soda,	(1·70)		·24	·06	·28	·04	·21	·02				·12	·09
Lime,	·09	·03	·13	·03	·18	·02	·09	·01				·09	·27
Magnesia,	1.33	·29	·46	·11	·26	·03	·10	·01				·44	·45
Br. Ox. Manganese,	·30	·06	·00	·00	·00	·00	·00	·00				·06	·06
Ferric oxide,	18·76	4·06	4·76	1·11	2·34	·29	1·03	·14				5·60	5·11
Alumina,	18·19	3·97	4·32	1·04	2·64	·33	1·21	·17				5·51	8·09
Phosphoric acid,	·18	·04	·11	·02	·03	·00	·02	·00				·06	·21
Sulphuric acid,	·06	·01	·02	·01	·03	·00	·03	·00				·02	·02
Volatile matter,	9·00	1·33	5·61	1·43	1.72	·23	·92	·29				3·64	3·14
TOTAL,	100·14	21·64	99·30	23·56	100·00	12·54	100·21	13·67		13·10		98,28	100·63
Total Soluble matter,	75·18		20·52		10.32		5·16						
" " Bases,	41·84		10·44		5·99		2·76						
Soluble silica in crude substance,	·38	0·01											0·19

A. Calculated on the amount of Sediment. B. Calculated on the amount of Soil.

It appears from these analyses that the "clay" is by far the richest in mineral ingredients, the amount being more than twice that of the others combined. Its insoluble residue is very small, while the soluble portion consists largely of free silica derived from hydrous silicates of the bases.

Its volatile matter (which includes hygroscopic moisture left after drying at 100° C., and water of hydration) is of course the largest; as are also the remaining ingredients, except lime. The large amount of soda, however, is due to the chloride used in the precipitation of the diffused clay.

In the other sediments, the soluble ingredients, except soda and lime, decrease in almost a geometrical ratio; there being also a corresponding increase of sand.

There are several interesting points in connection with this ratio of decrease which may be summed up as follows.

1. The iron and alumina exist in almost identical relative proportions in each sediment; making it probable that they are in some way definitely correlated.

2. Potash and magnesia also exist in almost the same quantities, and their ratio to each other in all the sediments being almost constant seems to indicate that they occur combined, perhaps in some zeolitic silicate, which may be a source of supply to plants.

3. Manganese exists only in the clay, a mere trace being found in the next sediment.

4. The lime appears to be "nowhere," having probably been largely dissolved, in the shape of carbonate, by the large quantity of water used in elutriation. Its increase in the coarser portions may be owing to its existence in the crystallized form, not so readily soluble.

In a general summation of the ingredients in the several sediments and comparison with the analysis of the soil *per se*, there is a loss in potash, magnesia and lime: which may reasonably be supposed to have been dissolved by the water of elutriation.

Some of the soluble silica clearly remains undetermined in the coarser sediments.

The differences in ferric oxide and alumina, shown throughout the analyses of this soil, may partly be accounted for by the unequal distribution of the particles of iron ore existing in the soil.

Of course the law of distribution of soil ingredients may differ in other soils; but the great distance from the point of derivation of the materials, and the wide distribution of the soils of which this is a type, probably render the above results of more than local applicability.

ART. IV.—*On the Influence of Strength of Acid and Time of Digestion in the Extraction of Soils;* by R. H. LOUGHRIDGE, of Oxford, Miss.

THE following investigation was undertaken with a view of determining the extent to which the variations likely to occur in the extraction of soils by hydrochloric acid, for the purpose of analysis, can influence the ultimate results; the special object being to ascertain the comparability of the analyses made in connection with the Agricultural Survey of Mississippi, both amongst themselves, and with those made by similar methods, by Dr. Peter, of soils collected by the Surveys of Kentucky and Arkansas.

In beginning the analyses of Mississippi soils in 1859, Dr. Hilgard adopted the following method, which has also been adhered to by his successors in this work, in over two hundred analyses made.

The soil (*i. e.*, "fine earth") is pulverized with a wooden pestle and thoroughly mixed. The hygroscopic moisture is determined, after exposing it in a space saturated with vapor, in a layer not exceeding 1^{mm} in thickness, for twelve hours, by drying at 200° C. in a paraffine bath. Of this dried substance from two to three grams are usually used in the general analysis, the methods employed being in general those adopted by Dr. Peter.* In another portion, after ignition, the phosphoric acid is determined by digestion for five days with nitric acid at 100° C., evaporation, precipitation by ammonium molybdate, digestion at 100°, solution in ammonia and precipitation by magnesium sulphate.

For general analysis the soil is digested in hydrochloric acid of strength 1·115 (as a rule) at 100°. It is then evaporated to complete dryness, this adding another day to the digestion.

In the insoluble residue the soluble silica is determined by boiling with sodic carbonate. The alumina and ferric oxide are precipitated according to Rose's method of boiling, for the complete separation of manganese, magnesium and calcium. The mixed precipitate is treated with potassic hydrate.

After precipitation of the lime by ammonic oxalate, the ammoniacal salts are destroyed by Lawrence Smith's method, with aqua regia; and the residue converted into nitrates, from which sulphuric acid is precipitated by barium nitrate. The alkalies are then separated by treatment with oxalic acid, ignition and washing. In the residue, barium, manganese and magnesium are separated as usual.

* Ky. Report, vol. iii.

With the aid of a Bunsen's filtering apparatus we can, by this method, complete an analysis in five days, exclusive of digestion; and three analyses may be in progress at the same time.

The substance experimented upon was a subsoil, a typical representative of the best yellow loam uplands of Mississippi, from the table lands of Benton Co., Miss.; No. 219 of the Survey Collection.*

To determine the question as to whether such variations in the *strength* of the acid, as might possibly have occurred in the use of the steam-distilled (i. e., from a retort surrounded by steam) product, without previously ascertaining its concentration, portions of the subsoil were digested five days with hydrochloric acid of the strength, severally, of 1·100, 1·115 (the normal concentration) and 1·160.

As to the *time* during which the soil must be digested in hydrochloric acid that the (sensible) limit of its solvent action upon the important soil ingredients may be reached, Dr. Peter's practice has been to digest for about ten days, in his 800 analyses of Kentucky and Arkansas soils; while for reasons of convenience, half that time has been adopted in the analyses of the Mississippi Survey. The question whether, under these circumstances, the two series can be deemed comparable, was approached by digestions, for periods of one, three, four, five and ten days, of the same soil with the same large excess of acid of 1·115; all precautions being taken to accomplish each analysis as nearly as possible under the same circumstances.

For the digestions, use was made of porcelain beakers (the use of glass being objectionable because of its solubility); the same amounts (40^{ccm}) of acid were used, and steam kept up about twelve hours each day.

The hour of "putting down" was carefully noted, and at the end of the allotted time the solution was poured off from the insoluble residue, and each evaporated to dryness separately and reunited in solution, to prevent any further action of the acid.

This result points to the conclusion, that while lime and magnesia (being readily dissolved) are probably present chiefly as carbonates or hydrocarbonates, potash as well as alumina, and to some extent lime, are present as silicates, and for that reason are not as fully extracted by acid of low strength as by that of 1·115; although the former acts more powerfully than that of 1 160

The latter fact (the coincident result of two analyses), though unlooked for, is not without analogies, although its precise

* The analysis of the subsoil of a neighboring tract is given in Hilgard's Report, 1860, p. 292.

cause, in this case, still requires elucidation. Whether the maximum of action is exerted by acid of 1·115, is another question of some interest, to be determined hereafter.

The results of the investigation as to strength of acid are as shown in the following table:

Ingredients.	Sp. Gr. of Acid.		
	1·10	1·115	1·160
Insoluble Residue,	71·88	70·53	74·15
Soluble Silica,	11·38	12·30	9·42
Potash,	·60	·63	·48
Soda,	·13	·09	·35
Lime,	·27	·27	·23
Magnesia,	·45	·45	·45
Br. Ox. Manganese,	·06	·06	·06
Ferric Oxide,	5·15	5·11	5·04
Alumina,	6·84	8·09	6·22
Sulphuric Acid,	·02	·02	·02
Volatile Matter,	3·14	3·14	3·14
	100·02	100·69	99·29
Amt. of Soluble Matter,	24·00	27·02	22·27
Amt. of Soluble Bases,	13·50	14·70	12·83

It thus appears that in the strongest acid the amount of insoluble residue is far greater than in either of the others, and that the difference lies chiefly in the soluble silica and alumina (i. e., clay), together with potash and lime. The other ingredients seem to be indifferent as to the strength of the acid.

Between the acids of strength 1·10 and 1·115 the difference is not so great, but the advantage is clearly with the latter, the amounts of silica, potash and alumina being greater, while the lime remains the same in both.

As for the comparability of the analyses as affected by the probable variations of strength of acid, I remark that the acid used for distillation by Dr. Peter, as Dr. Hilgard informs me, was the "C. P." of commerce, whose strength rarely much exceeds or falls below that of 1·115; while that used by us was usually the crude, diluted nearly to the same strength. The first and last portions coming over were habitually, I believe, rejected in either laboratory. Under these circumstances, it is very improbable that either of the extremes of sp. gr. above discussed ever actually occurred; especially as regards the stronger acid, which being in small quantity, would always be mixed with the succeeding weaker distillates.

It is therefore not probable that the percentage of potash or other important ingredients could have been so far underestimated in either of the series of analyses, as to seriously influence their comparability, either within themselves, or with each other.

The experiments on the influence of the time of digestion, made with acid of 1·115, resulted as follows:—

Ingredients.	No. of Days Digested.				
	1.	3.	4.	5.	10.
Insoluble residue, ------	76·97	72·66	71·86	70·53	71·79
Soluble Silica, ----------	8·60	11·18	11·64	12·30	10·94
Potash, --------------	·35	·44	·57	·63	·62
Soda, ----------------	·06	·06	·03	·09	·28
Lime, ----------------	·26	·29	·28	·27	·27
Magnesia, ------------	·42	·44	·47	·45	·44
Br. ox. manganese, -----	·04	·06	·06	·06	·06
Ferric oxide, ----------	4·77	5·01	5·43	5·11	4·85
Alumina, -------------	5·15	7·38	7·07	7·88	7·16
Phosphoric acid, -------				·21	·21
Sulphuric acid, --------	·02	·02	·02	·02	·02
Volatile matter, --------	3·14	3·14	3·14	3·14	3·14
Total, --------------	99·63	100·68	100·55	100·69	99·80
Amount of soluble matter.	19·67	24·88	25·57	27·02	24·87
" " " bases,	11·05	13·68	13·91	14·49	13·68

It thus appears, that the amount of dissolved ingredients increases up to the fifth day, the increase becoming, however, very slow as that limit is approached. It is also found that the ingredients offering the greatest resistance to this action are the same as those whose amounts were sensibly affected by the strength of acid, viz., silica, potash and alumina.*

In regard to lime and magnesia, one day's digestion not being sufficient for full extraction, it is evident that they do not exist in the soil as carbonates or hydric oxides only, as has been supposed; but also as silicates.

A comparison of the results of the five and ten day digestions shows that the solvent action of the acid has substantially ceased, there being no further increase of the amount of dissolved matter.

So far, therefore, as the time of digestion is concerned, the analyses of the Mississippi Survey are strictly comparable with those of Arkansas and Kentucky soils, made by Dr. Peter.

ART. V.—*On a new form of Cathetometer*; by WILLIAM GRUNOW.

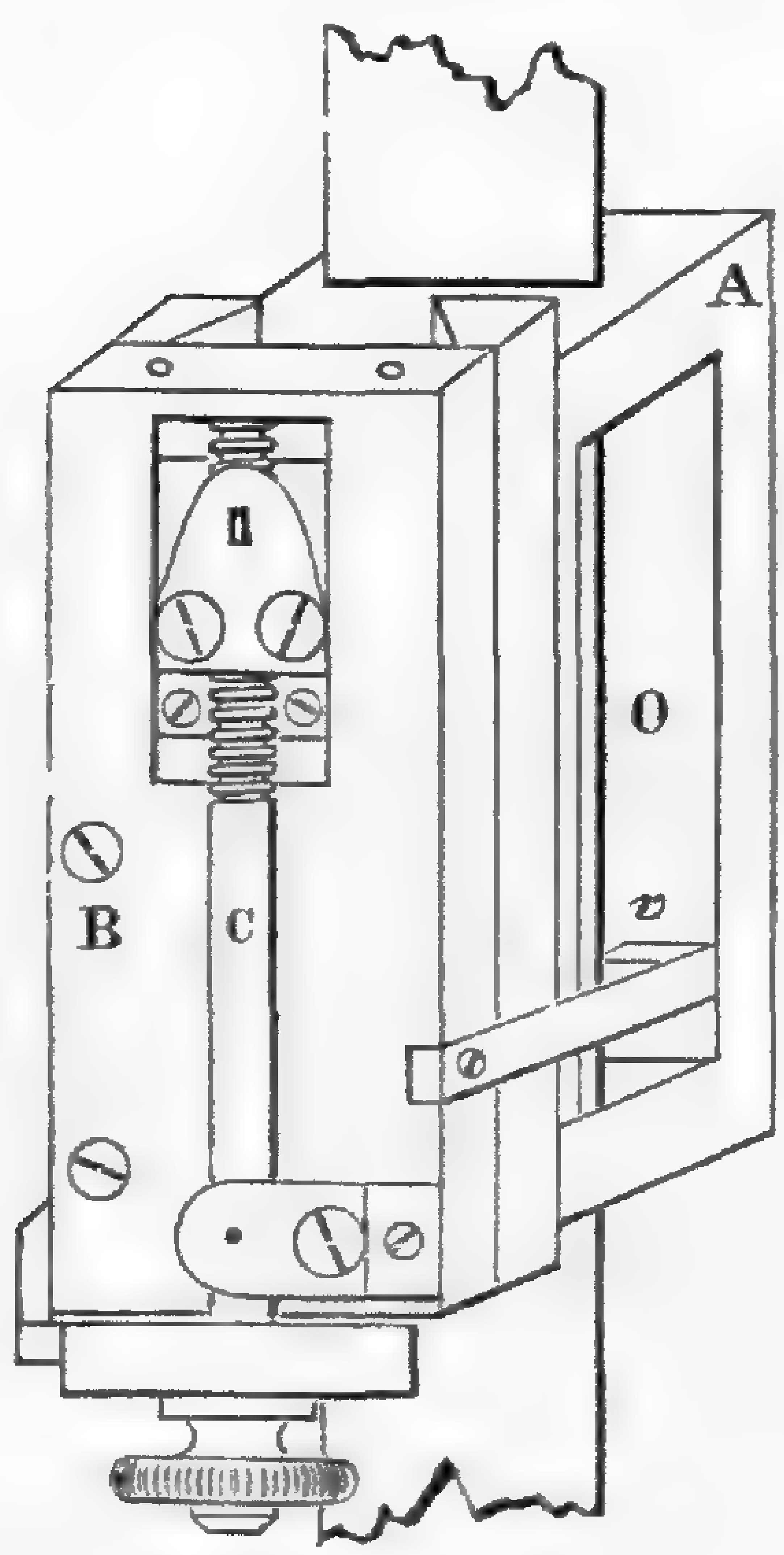
THE cathetometer consists essentially of a graduated vertical rod, on which slides a block supporting a leveling telescope. The block is commonly divided into two distinct pieces, both

* There is an apparent loss of alumina in the four days' digestion, owing to the lack of a second separation from iron, whose quantity is correspondingly increased.

sliding on the rod and placed over each other, one of them being provided with a clamp, and connected with its mate by a micrometer screw and spring, or by the former alone.

This form of fine adjustment seems to have been derived from that employed in the earlier compound microscopes, and though its manifest defects have long since caused its disuse with these instruments, it is still ordinarily employed in the construction of cathetometers.*

I have recently constructed, for the Physical Cabinet of Columbia College, a cathetometer, in which, by the use of another arrangement, great steadiness and accuracy of movement are attained, in combination with simplicity.



Upon a graduated, vertical, triangular brass bar, slides a *single* block, which carries the telescope and the micrometric arrangement for the fine adjustment. On one of the sides of this block, which is fastened in position by a thumbscrew, is dovetailed the slide B, which, being provided with adjusting screws, can be made to move steadily and accurately. The slide B is moved up and down the block A by the micrometer screw C, which is mounted in such a way that its motion cannot interfere with the steadiness of the movement of the slide B; it can also be adjusted so that it works without dead motion.

Each turn of the screw corresponds with one division of the graduated bar on which the block A slides. The slide B carries an arm with an index *v*, which moves in an opening O, cut out in the side of the block A corresponding to the graduation on the bar. The screw carries a movable head, divided into one hundred parts, and by means of its index, fractions of a turn of the screw or rather fraction of one division on the bar, can be read off easily and accurately. The leveling telescope is screwed on the top of the slide B.

* Compare Leçons de Physique, par M. P. Desains, vol. i, p. 12; Die Physik auf Grundlage der Erfahrumg, von Dr. Alb. Mousson. 2d ed., vol. i, p. 15; Lehrbuch der Physik und Meteorologie, von Dr. Joh. Müller, 6th ed., vol. ii, p. 569; Lehrbuch der Experimental Physik, von Dr. A. Wülner, vol. i, p. 43; Cours de Physique, par M. J. Jamin, 2d ed., vol. i, p. 36; Elementary Treatise on Natural Philosophy, American ed., p. 130, by A. P. Deschanel; and Allgemeine Encyklopaedie der Physik, 1 Band, p. 548.

The screw which I used for this instrument had a millimeter thread, and its head being divided into a hundred parts, gave hundredths of a millimeter.

In testing the instrument with the higher power, I felt gratified that measurements could actually be made to the hundredth part of a millimeter, and confirmed by repetition.

To make the instrument more generally useful, the objective of the telescope is provided with a draw-tube which adds four inches to its length, and permits observations to be taken at as short a distance as three or four feet. In addition, it is provided with a brass cap, which can be slipped over the mounting of the objective, and which carries a supplementary centered achromatic lens, which permits the instrument to be approached to within a distance of six inches from the object. When thus arranged it enlarges the actual dimensions of objects about forty diameters, but even with this rather high power, the smoothness and steadiness of the micrometric movement seems in no degree impaired.

Columbia College, Nov. 4th, 1873.

ART. VI.—*Notes on the Geology of Western Texas, near the thirty-second parallel;* by WALTER P. JENNEY, E.M., Geologist Texas and Pacific Railroad Survey in West Texas.

I. *On the occurrence of a remarkable Lower Silurian Section in the Organ Mountains.*

WHILE examining the mountains about two miles north of El Paso, Texas, which are a continuation of the Organ range southward from Solidad Pass, I was surprised to find a great development of the Paleozoic rocks, with the divisions between the strata of the different periods very distinctly marked, and each bed filled with an abundance of well-preserved specimens of its characteristic fossils.

The strata dip at an angle of about 20° to the west, toward the valley of the Rio Grande; and the upturned edges of the different beds form the eastern slope of the range, where, beginning at the foot hills at the base of the mountain, the section is as follows:

A. A coarsely crystallized red-feldspar granite, which extends along the whole length of the eastern base of the range, and where exposed has a thickness of 100 feet or more.

B. Gray quartzite, resting unconformably on the granite: the lower portion of this stratum is hard and compact, and contains some chlorite slate. but it merges as one ascends into a calcareous sandstone full of the borings in pairs of the *Scolithus linearis* of the Potsdam sandstone. The total thickness of this bed is about 250 feet.

C. Gray crystalline limestone, nearly 250 feet in thickness, resting conformably on the sandstone: in the lower part of the bed no fossils were found, but in the upper layers one or two species allied to *Archæocyathus* are abundant, which indicate its equivalence with the Calciferous sandrock. A few feet of sandstone weathering dark red separates this bed from the next in the series.

D. Gray magnesian limestone, about 450 feet in thickness, and containing much flint or hornstone; its characteristic fossils are a Receptaculite, and shells allied to *Orthoceras* and *Helicotoma*. On more extended examination, this bed may be identified as Chazy.

E. A black limestone, nearly 100 feet in thickness, forming the crest of the range: it rests conformably on bed D, and the contact is very distinctly marked. The black limestone is filled with well known fossils of the Trenton period, including *Maclurea magna*, species of *Orthis*, *Orthoceras*, *Cyrtoceras*, and corals allied to *Halysites* and *Syringopora*.

Passing over the top of the mountain and descending on the western slope, the next stratum in the series encountered rests on the Trenton limestone; but it contains forms of life which are totally different though no less abundant.

F. Gray limestone, which has been very much denuded, yet not less than 200 feet in thickness remains; in the lower part of the bed *Halysites gracilis*, species of *Syringopora*, *Zaphrentis* and several other corals, together with *Rhynchonella increbescens* were found, and in the upper part many varieties of Brachiopods, among which were *Strophomena rugosa*, species of *Leptæna* and several of *Orthis*, which identify it with the Hudson period.

G. A coarse conglomerate, composed of rounded and angular fragments of the Trenton and Hudson limestones cemented together by carbonate of lime and sand: it is of varying thickness, being in some places 60 feet thick and in others entirely wanting in the series. It rests unconformably on both the Trenton and Hudson beds, and seems to contain no fossils; but from its position it may possibly be equivalent to the Oneida conglomerate of New York.

H. A ridge of light gray crystalline limestone extends along the western base, parallel to the crest of the range, and rests unconformably on the conglomerate and the Trenton and Hudson beds: its thickness is about 400 feet, and the dip is only 10° to the west. These facts show that it was deposited after a partial uplifting of the underlying beds, and that subsequently the range has attained its present elevation. Owing to the crystalline character of the limestone, nearly all traces of life are destroyed; but a few fragments of imperfect shells resembling a *Pentameras* were found near the contact with the conglomerate, so that the lower portion of this bed may be of Niagara age: but the resemblance of the limestone of the upper part of this ridge to that of Carboniferous age in the parallel range of the Hueco Mountains leads me to think that, on a more extensive examination, it will be found to be equivalent to it.

Dr. G. G. Shumard seems to have examined this same range, but at a point farther north. He mentions the occurrence of a limestone of Trenton and Hudson age succeeded by the Carboniferous. (Dana, Manual of Geology, p. 245.)

About two miles west of this locality, on the banks of the Rio Grande, are very interesting beds of Cretaceous age, through which the river has cut its present channel. These beds have been described in the reports of the survey of the Mexican Boundary.

In the parallel range of the Hueco Mountains, 20 miles east of El Paso, the section is similar but less distinctly defined: the dip of the strata is to the east, so that the upturned edges of the beds in the two ranges face each other.

A limestone of Carboniferous age forms the crest of the Hueco range, and rests on a magnesian limestone containing many fossils of the *Orthis* family, resembling Hudson or Niagara forms; but, though a careful search was made at the contact of the Silurian and Carboniferous limestones in the Organ, Hueco and Guadaloupe Mountains, no strata containing any Devonian forms of life were found. It appears, therefore, that the greater portion of the Upper Silurian and the whole of the Devonian periods are unrepresented in the rocks of Western Texas.

An immense development of Carboniferous strata occurs in the Sacramento and Guadaloupe Mountains, between the Pécos and Rio Grande; at Guadaloupe Pass, about 800 feet of sandstone underlie a precipice nearly 600 feet high of Carboniferous limestone, above which the peaks of the mountain rise to perhaps an equal height.

At the banks of Los Cornudos, seventy miles east of El Paso, a water-worn mass of syenite, covering nearly a square mile of area, rises from the plains to a height of several hundred feet: resting against its base is a limestone of Carboniferous age, containing several species of *Productus;* the limestone has filled crevices a foot in width in the syenite, in which several small spiral shells, species of *Pleurotomaria* and *Helicotoma* were found. As there are no indications of limestone having ever been deposited except near the base of the Cornudos, a portion of this rock may have been above water in the Carboniferous sea.

II. *The Llano Estacado, or Staked Plains.*

A great deal has been written about this desert, which stretches north and south nearly 350 miles, and, from the head waters of the Rio Colorado and its branches westward, from 50 to 150 miles, to the Rio Pécos. Its underlying strata were announced to be Triassic and Jurassic by Jules Marcou, but are now well known to be of Cretaceous age A fine section of the Llano is exposed at Castle Cañon, near Horsehead Crossing of the Pécos: the strata, beginning at the base, are arranged as follows:

1. A coarse red sandstone without fossils, but probably of Triassic age, 50 feet exposed.

2. Soft calcareous brown sandstone, with fragments of fossil shells: this bed is 50 feet in thickness and probably of Cretaceous age.

3. Soft yellow limestone, 450 feet in thickness, containing an abundance of well known Cretaceous fossils, including *Gryphea Pitcheri*, *Exogyra Texana*, *E. Arietina*, *Arcopagea Texana*, *Ammonites Pedernalis*, and several species of *Cardium*, *Nerinæa* and *Pecten.*

4. Compact yellow limestone, 30 or more feet in thickness, wanting at Castle Cañon, but forming the tops of the highest hills on the Llano, and also found on the tops of the mountains in Jones County.

The characteristic fossil of this bed is the *Caprina crassifibra*, which is very abundant; the bed is, I think, equivalent to the "Caprina limestone" of Shumard, and is the most recent member of the Cretaceous in Western Texas. The Cretaceous beds on the banks of the Rio Grande, at El Paso, contain fossils identical with those from bed 3. Similar sections to that of the Llano were found at Fort Chadbourne, in the neighboring mountains, which were identical both in the arrangement of the strata and in the fossils from the different beds.

In Mason County, underneath the limestone and red sandstone, there is a metamorphic sandstone resting unconformably on micaceous gneiss. The hardness of the upper layers of limestone has greatly protected this formation from denudation, and given the "mesa" character to the hills, as the bedding is almost horizontal; but there can be no doubt that formerly this formation was much more extensive, and that the flat-topped hills and ranges of low mountains which are found east of the plains, almost as far as Austin, were islands in the sea which produced the denudation, their tops showing no evidence of having ever been submerged, and in some places wave-worn cavities extend at the same height along their sides.

ART. VII.—*On the Formation of the Lignite Beds of the Rocky Mountain region*; by L. LESQUEREUX.

FROM a report which is apparently reliable, but which I have not seen in print yet, a prominent geologist has advanced the opinion that the so-called lignite beds of the Rocky Mountains have been formed by the heaping of drifted materials. This opinion, says my informant, is sustained by the following facts:

1st. That the lignite beds are of too small extent, or cover too limited areas, to have been formed otherwise than by the heaping of materials carried into small basins.

2d. That the *under clays* of the lignite beds have no roots.

I do not wish, of course, to review the old hypothesis on the formation of coal and lignite, as exposed in a masterly manner and sustained by Bischoff; but only to answer the two above objections.

1st. It is evident, from all that has been ascertained of the lignitic basin of Clear and Boulder Creeks, by Hayden, Hodge and myself, that this productive lignite basin extends from the South Platte to Cheyenne, a distance in a direct line of more than one hundred miles. The width of this basin is not ascertained; but lignite beds have been found in borings thirty miles east of the mountains, or those of Golden and Boulder City. As yet, it is not positively known whether a continuous bed of lignite occupies the whole area; for this basin has from eight to sixteen beds in its whole thickness. This, however, I have seen this year. The main coal of Golden is continued south to Clear Creek, and has been tested all along for a distance of nine miles; and northward the same bed is recognized continuously for seventeen miles to north of Boulder Creek, where it is covered by conglomerate beds. This is extensive enough, I think, for a bed of lignite measuring generally from eight to fourteen feet in thickness. The lignite beds have been cut through by prodigious denudations. They have also been destroyed at many places, either partially or entirely, by combustion. The country around Black Butte, and from this place to Green River, is covered by hills, often composed of baked red shale or sandstone, etc., all changed by heat or by the combustion of beds of lignite. Local occurrences of this kind have considerably and locally reduced in extent the area of strata of combustible materials, and broken their continuity. The large or thick main coal of Black Butte has been destroyed in this way on its eastern side; and here its shale and sandstone are metamorphic, or as hard as steel, while on the other side, where the coal has been preserved, they have their natural softer composition. But even if the lignite beds were proved to be of little horizontal extent, this would be no objection against the supposition of their origin as peat deposits. The emerged peat formations are generally of this kind. It is indeed the general case that peat bogs now cover hollows of limited areas rather than wide surfaces. The peat bogs formed in water along the shores of lakes or near the mouths of great rivers, are only occasionally of wide extent. The deep peat bogs of Germany, Denmark and Scandinavia, where wood is found heaped by the growth of successive forests to the depth of seventy to one hundred feet, are mostly deposits covering from one to ten acres of ground.

2d. I can say, from repeated and personal observations, that most of the lignite beds of the west which have passed under my examination have the under clays full of rootlets or of roots of the floating plants which were the first, generally at least, to contribute to the formation of the bed of combustible material by their debris. At the Raton Mountains, at Cañon City, at Gehrung's near Colorado, at Golden, Marshall, Black Butte, etc., the coal is everywhere underlaid by chocolate-colored shale, often a compound of these roots or rootlets, so compact indeed that they cannot be determined, nor their forms distinctly recognized. I have for this reason collected many specimens for microscopical examination. Of course, the undershales do not contain any roots (true roots of trees); the coal of the Carboniferous, too, never has any; for the good reason that trees do not grow in water, and that they only invade peat bogs when the ground is solid enough to support them. And even then the roots grow horizontally, and do not descend deep into the matter, which, generally impregnated by water, is to a degree inaccessible to atmospheric influence. The so-called roots of the clay beds of the Carboniferous measures, or the *Stigmaria*, are not roots but floating leaves. And even their cylindrical stems are rarely found in clay beds; only their leaves fill them, just as the radicles of water plants fill the clay of the Tertiary lignite. It is, however, a fact that some of the lignite clay beds, and those of the Coal-measures too, are clean or without admixture of vegetable remains, even of rootlets. But, when the peat is beginning its growth at the surface of a somewhat deep basin of water, whose bottom has been rendered impermeable by the deposit of clay (which always precedes the deposit of woody materials), this surface peat is often thick and compact before it is forced down and comes in contact with the clay; and in that case, therefore, the clay is pure or is not penetrated by roots or rootlets.

The theory of formation by drifted matter cannot give an explanation of this fact: that the bottom clay is perfectly distinct from the coal or lignite matter, at the point of its surface where it is touched or overlaid by coal or lignite. There is no insensible transition from bottom clay to coal. Bischoff, as is well known, explained the differences in coal (pure as it is, indicating only a proportion of ashes equal to that of the wood) by supposing that after being drifted into a comparatively quiet basin of water, the heaviest particles of matter, sand and mud, had been first washed down to the bottom, and that the woody fiber, rather lighter, had been deposited afterward. In this case, the heaping of the matter would, of necessity, show a gradual transition in ascending, still higher up, from clay beds to clay and woody filaments mixed together, these successively becoming less impure. The heaviest coal should, therefore, always be at the bottom, the pure woody matter at the top. Who has seen in our lignite beds or coal beds anything like this? But of this hypothesis it is useless to speak further. It is set aside by facts and considerations a review of which would fill a volume.

There are of course some beds of impure lignite, whose origin is due to drifted wood, especially along large rivers. One is known at the mouth of the Rhone in France. I have seen some deposits of the kind in southeastern Arkansas, near the Washita River. The great Red River obstructions may become in time lignite deposits. But all formations of this kind show their origin by their composition: sand mixed with carbonized matter, sandy bottom, perforated too in various directions by drifted stems, etc. Nothing of this kind has been observed in the beds of lignite of the west, at least not in those which have come under my examination.

Columbus, Ohio, Nov. 16, 1873.

ART. VIII.—*On remains of Land Plants in the Lower Silurian;* by LEO. LESQUEREUX.

FROM a recent discovery, it now seems that traces of land vegetation exist in the Lower Silurian strata of this country. A few months ago, I received from Rev. H. Herzer* two specimens representing branches or small stems of a species referable to *Sigillaria*, and reported to have been found by Dr. S. S. Scoville on Longstreet Creek, near Lebanon, Ohio, in clay beds positively referable to the Cincinnati group of the Lower Silurian. The discovery of the remains of land plants in this for-

*** Well known through the discovery of some remarkable animal and vegetable remains in the Devonian of Ohio.**

mation is too remarkable a fact to be accepted without positive evidence. Being at that time about to take the field for geological explorations, I merely took a sketch of the specimens and returned them to the owner, purposing to examine more closely into the matter at a future time, either by going to Lebanon or by corresponding with Dr. Scoville. On my return, as Rev. Mr. Herzer had parted with the specimens, I sent to Dr. Scoville a sketch of the fossil under consideration, in order that he might recognize it, if it had been in his hands, and with the request to positively state whether he himself found the specimens, and when, and whether he had any more of the same kind. In his answer he writes: "I can say now most emphatically, that I found in Longstreet Creek, about six miles east of Lebanon, a fossil which resembles the sketch accompanying your letter in all the essential features. The specimen was, I think, in two pieces, or perhaps Mr. Herzer took only one piece. I know within a rod or two where it was found. Its position or horizon, in the Lebanon beds, was about the middle. Should any one question the accuracy of my statement in regard to the discovery of a specimen of this character, in the locality designated, I would refer them to Mr. S. R. O'Neall of this place, who has paid much attention to geology, and who will support my assertion, so far, at least, as to say: that I have described to him several times, and even but a few days since, the specimens under consideration."—In a postscript to this letter, Mr. O'Neall confirms the statement in regard to the specimens in question.

There can be therefore no doubt as to the locality where these vegetable remains have been found, or the geological age of the strata. The clays of the Lebanon beds are full of Trilobites of the same species that abound in the clay beds at the base of the Cincinnati group—*Calymene senaria.* The only question to be settled is the true character of the plant which the specimens represent.

As I have said above, there were two fragments of small stems or branches, referable to the same kind of vegetable; one, more complete, about two inches thick, cylindrical, the whole substance transformed into soft gray clay, the bark, or the outer surface only, distinctly moulded into clay, as is generally the case in specimens of this kind, and marked by rhomboidal, continuous, enlarged bolsters, surrounding the stem in a spiral, bearing at the middle a small oval or rhomboidal scar, less distinct, however, though well recognizable, and presenting the characters of stems of *Sigillaria Serlii* Brgt. or *S. Menardi* Brgt. The study of the specimens, as far as I was able to do it, left me undecided only in regard to their positive reference to the one or the other of these two species, on account of the somewhat obscure form of the internal scars. Though the Cincinnati group has remains of Fucoids of large size, none has, as yet, been found there to my knowledge, as large as these stems. And the peculiar form of the bolsters, placed in spiral around the stem, similar in form, equal in size, regularly convex, preclude the supposition that the remains represent some new kind of marine plants, or are attributable to a concretionary structure. We have therefore to admit them as representative of land plants, and thus to recognize the existence of traces of land vegetation in the Lower Silurian, the lower part of the Cincinnati group being the equivalent of the Trenton group of New York.*

This discovery is the more remarkable since we have, as yet, no records of vegetable remains from the Silurian of North America, except fragments of stems and rhizomes of *Psilophyton*, observed by Dawson in the Gaspé group of Canada. On these, Dr. Dawson remarks:† "Accordingly, it is in Gaspé that as yet we have the only link of connection of the Erian (Devonian) flora with that of the Silurian period. In the marine limestone of Cape Gaspé, holding shells and corals of Lower Helderberg age, along with some indeterminable plants, probably Fucoids, we have, as already stated, fragmental stems and distinct rhizomes of *Psilophyton*, some of them showing the scalariform axis well preserved. These fragments must have been drifted from the land; and, as in the immediately succeeding Lower Devonian beds, *Psilophyton* is associated with *Prototaxites*, *Arthrostigma* and *Calamites*, but is the most abundant of the whole, it is not unlikely that in the Upper Silurian land, it was associated with plants of these genera." In Europe too, the first remains of land plants have been found in the Lower Devonian, and as yet only a single specimen of a *Sigillaria*, described by Göppert as *S. Hausmannana*.‡ It was found as early as 1806, by Hausmann, during his geological exploration of Scandinavia, in a red Devonian quartzite just above strata of the Upper Silurian, where *Favosites polymorpha* was identified. Göppert, from whom these details are quoted, remarks that, on account of the presence of this species of *Favosites*, Murchinson admitted these strata to be Lower Devonian.

With the exception of the Lebanon specimen, the geological

* The occurrence of vegetable remains in clay beds abounding in remains of Trilobites is not subject to objection. The Coal-measures of the West have strata of shale, clay, limestone, even sandstone, where animal and vegetable remains are found together in abundance. I have found Trilobites in the shale overlaying coal beds at Summit Portage, Pennsylvania, with *Sigillaria*, *Stigmaria*, etc., and species of the same kind of animals, with plants too, in sandy clay beds of the upper Coal-measures of Indiana.

† Fossil plants of the Devonian and Upper Silurian formations of Canada, Pamphlet, 1871, p. 78.

‡ Flora der Silurischen, der Devonishen, etc., oder des sogenanten Uebergangsgebirges, p. 543.

formations of the United States have not afforded as yet any records of land plants earlier than those of the Lower Devonian. In Ohio and Kentucky, vegetable remains of this kind have been found at different places, mostly in concretions, including trunks or fragments of wood representing species of Conifers of the section of the *Araucariæ*, together with Lycopodiaceous plants; *Stigmaria*, *Sigillaria* and *Lepidodendron*. In Pennsylvania, a *Lepidodendron*, *L. primævum* Rogers, and a *Sigillaria* have been obtained from the same horizon. These fragments are as yet rare, and have not been satisfactorily determined, on account of the imperfect character of the specimens, mostly petrified pieces of wood, whose structure is studied with difficulty. It is certain, however, that in the Middle Devonian we have representatives of three distinct groups of vegetables: the Cellular Cryptogams, in a quantity of marine plants, the Vascular Cryptogams, in Lycopodiaceous plants: *Lepidodendron*, *Sigillaria*, etc., and the Phænogamous Gymnosperms, in the *Conifers*.

ART. IX.—*On a Combination of Silver Chloride with Mercuric Iodide;* by M. CAREY LEA, Philadelphia.

IN the course of an extended examination of the compounds formed by mercuric iodide, I some time since obtained two which I believed to be new. After having studied their properties, I found that one of them, a compound of the iodides of silver and of mercury, had previously been obtained by Meusel. I shall therefore here describe only the compound which mercuric iodide forms with silver chloride.

If to a portion of recently precipitated and still moist silver chloride, a considerably less quantity of mercuric iodide, also freshly precipitated and still moist, be added, we shall find that, after stirring them thoroughly together, the scarlet color of the mercuric salt is still plainly visible through the mass, which is of a bright salmon color. By standing some hours or a day, a remarkable change takes place, the red color wholly disappears and the powder became pure lemon-yellow. Before this change took place, the separate particles of the mercuric iodide could be plainly distinguished with a lens; after it, the powder becomes perfectly homogeneous. Fresh portions of mercuric iodide added, gradually disappear in the same way, until an equivalent quantity has been used.

A better plan, however, for preparing the substance consists in adding to a solution of a weighed quantity of potassic iodide an exactly equivalent quantity of mercuric chloride, and then, after thoroughly agitating and allowing the precipitate to fall, adding an equivalent quantity of silver nitrate, also in solution. The potassic chloride formed by the first reaction is exactly sufficient to throw down the whole of the silver as chloride. When the silver salt is added, one may remark three precipitates visible in the liquid, irregularly blended, scarlet mercuric iodide, white silver chloride and the yellow substance resulting from their combination. The precipitates are then to be thoroughly stirred together to promote combination, which, however, is not complete for about twenty-four hours. Meantime the mixture is salmon colored from the presence of free mercuric iodide.

Obtained in this way, the substance appears as a heavy yellow powder, wholly free from any trace of red, and rather inclining to a greenish or lemon-yellow. This color it always exhibits, no matter how prepared, while still wet, even if left for weeks. Mixed, however, with gum arabic and spread on card-board, it dries to a full chrome yellow. It could not be obtained in a condition sufficiently pure for analysis, but there can be little doubt that its constitution is $AgClHgI$.

The new substance exhibits remarkable properties with respect to heat. Even below 100° F. it begins to redden, and this change rapidly increases with the rising temperature until it reaches a maximum at about 140° F. At this temperature it has a bright scarlet color, differing, however, a good deal from that of mercuric iodide, and more resembling, if moist, that of chrome red; if dry, that of vermilion. As the temperature falls again, the pale yellow color returns. A striking experiment consists in placing a portion of the substance in a test tube under water, and warming it at a Bunsen's burner. The very instant that the flame touches the glass, the whole layer of substance in contact with it flashes to a bright red. If heated till it is changed throughout, a portion taken out with spatula and dropped on a cold porcelain dish, becomes yellow at the instant of contact.

If a portion of the substance be mixed with a solution of gum arabic and be spread on card-board, it exhibits the following properties:

Warmed gently at a lamp (best by holding it near the glass chimney of an Argand burner), it assumes a deep red color; then, when removed, it recovers its yellow shade. Both changes take place so rapidly that the alteration of color may be watched, and is complete in a few seconds or half a minute. If instead of gently warming, a strong heat be applied, just below what is sufficient to char the card, the portion thus strongly heated assumes a still deeper color, and returns to the yellow much more slowly, retaining an intermediate orange shade for some hours. This change is brought about by a sudden and momentary heat: if the heat be continued, the mercuric iodide volatilizes, and the portion so treated becomes permanently yellow.

If one of these cards be exposed to sunlight with a portion perfectly protected, the exposed part becomes slightly darkened. This effect takes place with an exposure of half an hour or less and is scarcely increased if the exposure be prolonged for many hours. By keeping for a few days in the dark, the deepening of color gradually fades out until the exposed parts are not to be distinguished from the rest. This effect may be repeated several times with the same card.

In reference to the compound of silver iodide with mercuric iodide, I feel constrained to differ from Meusel, who considers it only a mixture and not a combination. I take it to be a compound, though an extremely loose one, and for the following reasons, which apply equally to the silver chloride compound.

So long as the substances are only mixed, and before they have united, the characteristic color of the mercuric iodide is always conspicuously observable, and no mechanical mixing, however thorough, is capable of concealing it. The eventual disappearance of this color seems to be a proof of combination. This view is farther strengthened by what takes place in the case of *silver bromide.* When HgI is placed in contact with AgBr, no combination takes place as in the case of AgCl and AgI under similar conditions. Even after many days the color of the mercuric salt is conspicuously visible. In one case I kept HgI in contact with excess of AgBr, both freshly precipitated, for several weeks under water, at the end of which time the particles of HgI could be distinguished under a lens with perfect facility. At the end of weeks, the mixture of AgBr and HgI retains exactly the appearance which it presents when first mixed (supposing, of course, that it has been protected from the light). AgCl and AgI, when mixed with HgI, present at first the same appearance, which, however, subsequently changes completely, and a substance with new properties is the result. This seems clearly to indicate a combination.

The striking fact that the thermochromic properties of mercuric iodide are inverted in the new compound, which passes from yellow to red by heat, instead of from red to yellow, and the far greater sensitiveness to heat of the new substance, are strong arguments of combination.

Meusel's explanation of the change of color, in his view of mere mechanical mixture, makes it depend on a diminished power of absorbing red rays when warmed, which he ascribes to silver iodide. But the experiment which I have described with the substance spread on card-board disproves this explanation in two distinct manners.

At a temperature about 30° or 40° of Fahrenheit above the boiling point of water, mercuric iodide becomes yellow. If, therefore, the new substances were mere mixtures on being heated to that temperature the red color previously acquired should disappear completely, since there could be no possible cause for its continuance. The mere mechanical mixture of two yellow substances (in the case of AgI and HgI), or of a white and a yellow (in the case of AgCl and HgI), could by no possibility produce a red one. This single argument would seem to be sufficient in itself.

The peculiar persistency, after applying momentarily a high heat, seems also inconsistent with the hypothesis of a mechanical mixture. Let us follow the phenomena which present themselves and consider them in the light of this hypothesis of a mechanical mixture. The substance is at ordinary temperatures yellow; it is difficult to suppose that white and scarlet mechanically mixed can form yellow. At 140° F., it is deep red; now this rise of temperature makes no visible change in the color of either constituent, taken separately; if the mixture be merely mechanical, it is difficult to see why the color should change. At a still higher temperature, let us say for example 300° F., mercuric iodide is yellow, but the substance in question is deep red. And, whereas before we had white and red mechanically mixed forming yellow, now we have white and yellow forming red. Even the phenomena of persistence are reversed, for whilst mercuric iodide after cooling retains for a time its yellow color, and then passes to its normal red, this substance, after a strong momentary heating, retains for sometime after cooling its red shade, and eventually recovers its normal yellow.

These properties seem to be irreconcileable with the view of mechanical mixture. The behavior of the substance when exposed to sunlight also affords a strong argument. The very faint darkening caused, and the gradual recovery of the original color, seem inconsistent with the hypothesis of the presence of free silver chloride. There is no doubt that the combination is a loose one. By repeated boiling with a considerable quantity of water, most of the mercuric iodide can be dissolved out, and this may be still more easily done with alcohol, in which mercuric iodide is more soluble than in water. This, however, is, of course, no proof of absence of combination, as many compounds can be broken up in a similar way. Even after repeated boiling with water, a portion of the mercuric iodide is held back, and it is curious that the abstraction of the mercuric salt does not change the color of the residue. The silver chloride does not recover its whiteness, the yellow color remains unchanged, but the property of reddening by heat disappears with the removal of the mercuric iodide.

426 Walnut st., Philadelphia, Dec. 5.

ART. X.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XXVI. *Results of recent Dredging Expeditions on the Coast of New England.* No. 4; by A. E. VERRILL.

(Continued from vol. vi, page 435.)

VERY few localities of "hard" bottom were met with in more than 25 fathoms of water; and consequently we could not obtain so complete a knowledge of the fauna occupying such bottoms, at greater depths off that coast, as of that inhabiting the soft muddy bottoms. This has, however, been remedied to a considerable extent by some of the subsequent dredgings made by Dr. Packard, when on the Bache. Moreover, a considerable number of species belonging properly on rocky bottoms came up attached to the boulders, already referred to, which we frequently brought up even from the softest mud.

Other inhabitants of such bottoms were obtained from the stomachs of fishes, freshly caught. From these and other sources we could now compile a pretty full list of species belonging to the hard bottoms in depths between 50 and 125 fathoms, off the coast between Cape Cod and Mount Desert.

Two of our dredgings off Seguin Island, in 33 and 45 fathoms respectively, belong to the series of outer and deeper dredgings, rather than among those made in the bays. They are, however, somewhat intermediate in character.

The first named locality was unusually rich in species, and I therefore give the entire list obtained at that place, so far as they have been identified. The bottom was generally hard, and in places rocky, but some patches of mud were evidently encountered by the dredge, and consequently there is a considerable number of true mud-dwelling species in the list. Only one haul of the dredge was made at this locality, owing to unfavorable weather.

Contents of a single haul of the dredge made Aug. 13, 1873, *on hard bottom, with some spots of mud, in* 33 *fathoms; locality, six miles east of Seguin Island.*

ARTICULATA.

Arachnida.

Nymphon, sp.

Crustacea.

Hyas coarctatus.
Eupagurus Kroyeri.
Pandalus annulicornis.
Hippolyte pusiola.
Hippolyte spina.
Unciola irrorata.
Cerapus rubricornis.
Monoculodes, sp.
Metopa, sp.
Caprella, sp.
Praniza cerina.

Annelids.

Harmothoë imbricata.
Nicomache lumbricalis.
Nothria conchilega.
Phyllodoce catenula V.
Lumbriconereis fragilis.
Anthostoma acutum V.
Gattiola, sp.
Nereis pelagica.
Amphitrite Grœnlandica.
Cistenides granulatus.
Ampharete gracilis.
Ampharete, sp.
Vermilia serrula.
Arenia, sp.
Ninoë nigripes V.
Melinna cristata.
Thelepus cincinnatus.
Scione lobata.
Chone, sp.
Potamilla oculifera.
Sabella, sp.
Spirorbis lucidus.

Sipunculoids.

Phascolosoma cæmentarium.
Phascolosoma tubicola V.

Nemerteans.

Nemertes affinis.

MOLLUSCA.

Gastropods.

Admete viridula.
Bela turricula.
Bela harpularia.
Bela violacea.
Buccinum undatum.
Neptunea decemcostata.
Neptunella pygmæa.
Astyris zonalis V.
Trichotropis borealis.
Aporrhais occidentalis.
Velutina haliotoidea.
Lamellaria perspicua.
Lunatia Grœnlandica.
Turritella erosa.
Lepeta cæca.
Calliostoma occidentale.
Margarita cinerea.
Diadora noachina.
Doris planulata.
Hanleia mendicaria Carp.
Entalis striolata.

Lamellibranchs.

Saxicava arctica.
Macoma sabulosa.
Cardium Islandicum.
Cardium pinnulatum.
Cyprina Islandica.
Astarte undata.
Astarte elliptica.
Astarte lens.
Cyclocardia borealis.
Crenella glandula.
Modiolaria discors.
Modiolaria corrugata.
Leda tenuisulcata.
Pecten Islandicus.
Nucula tenuis.
Anomia aculeata.

Ascidians.

Ascidiopsis complanatus.
Glandula arenicola.
Molgula pannosa.
Leptoclinum luteolum.
Leptoclinum albidum.
Amarœcium glabrum.
Lissoclinum, sp.

Brachiopods.

Terebratulina septentrionalis.

Bryozoans.

Tubulipora crates.
Idmonea pruinosa.
Crisia eburnea.
Discofascigera lucernaria.
Caberea Ellisii.
Gemellaria loricata.
Flustra solida.
Cellularia ternata.
Cellepora scabra.
Cellepora ramulosa.

RADIATA.

Echinoderms.

Lophothuria Fabricii.
Strongylocentrotus Dröbachiensis.
Solaster endeca.
Asterias vulgaris.
Stephanasterias albula V.
Leptasterias, sp.
Cribrella sanguinolenta.
Ophiocnida hispida.
Amphipholis elegans.
Ophiopholis aculeata.
Ophioglypha Sarsii.
Ophioglypha robusta.

Acalephs.

Lafoëa fruticosa.
Lafoëa dumosa.
Halecium, sp.
Grammaria robusta.
Sertularia argentea.
Sertularia latiuscula.
Sertularella polyzonias.
Eudendrium tenue.

Polyps.

Urticina crassicornis.	Cornulariella modesta V., new genus and sp.*

PROTOZOA.

Sponges.

Tethya hispida.	Reniera, sp.	Grantia ciliata.
Halichondria, several sp.		

Foraminifera.

Numerous species.

ALGÆ.

Laminaria longicruris.	Agarum Turneri.	Desmarestia aculeata.

The 45 fathom locality was about five miles southwest from Seguin Island. At this place we dredged many of the species enumerated in the above list, together with a number of additional ones, among which were the following:

Crustacea.

Hippolyte aculeata.	Diastylis quadrispinosa.	Balanus porcatus.
Ptilocheirus pinguis.		

Annelids.

Nephthys, sp.	Trophonia aspera.	Terebellides Stroëmi.
Rhynchobolus albus.	Ammochares, sp.	Myxicola Steenstrupii.

MOLLUSCA.

Bela decussata.	Margarita obscura.	Eugyra pilularis.
Natica clausa.	Cylichna alba.	Amarœcium pallidum.
Scalaria Grœnlandica.	Yoldia thraciformis.	

RADIATA.

Cerianthus borealis V.	Eudendrium ramosum.

A number of dredgings were made on and near East and West Cod Ledges, several miles off Cape Elizabeth. The shallower parts of these in 10 to 15 fathoms, are very rough and rocky, so that in some places the dredge could not be used, and even the tangles suffered seriously by the iron frame becoming caught and jammed among the rocks so firmly that

* *Cornulariella modesta* V.

Allied to *Cornularia* and *Telesto*. Polyps tubular, rising from creeping stolons; lower part of the polyp-bodies has the walls thickened and stiffened by numerous large fusiform spicula, with sharp conical projections, and is more or less eight-ribbed in contraction; upper part of body hour-glass shaped, flexible, translucent, whitish, with fewer white spicula, retractile into the lower part, the eight internal lamellæ showing through. Tentacles large, expanding about 6^{mm}, lanceolate, gradually tapering to the acute tips, flat above, with the short thick pinnæ arranged along the upper edges on the distal half; the lower side of the tentacles is rounded and more or less swollen toward the base. Color of stolons and base of polyps dirty yellowish or brownish; flexible part of polyps and the tentacles translucent white; the latter with central rows of white spicula. Height of polyps, 6^{mm} to 18^{mm}: diameter, 3^{mm}; distance between polyps, 6^{mm} to 25^{mm}; breadth of stolons, about 3^{mm}.

Casco Bay; Bay of Fundy, 80 to 100 fathoms. Gulf of Saint Lawrence, in deep water (Whiteaves).

it could not be extricated without using force sufficient to bend and twist the stout iron cross-bar; at somewhat greater depths, in 20 to 30 fathoms, farther away from the crests of these ledges, the bottom was generally stony and gravelly, though often rough, and the dredges were used with good success. Most of the species from these localities have been enumerated in the two preceding lists, and need not be repeated here, but a considerable number of additional ones occurred. The roughest parts of the ledges, in 10 to 15 fathoms, are overgrown with red algæ, and among these the reddish variety of cod, known as "rock-cod," abounds. Here also a large number of interesting crustacea were obtained, most of them having red colors, evidently adapting them for concealment among the algæ. Among the crustacea were the following:

Hyas coarctatus.	H. Phippsii.	Unciola irrorata.
Cancer irroratus.	H. pusiola.	Amphithoë, sp.
Eupagurus Kroyeri.	Crangon boreas.	Caprella, sp.
E. Bernhardus.	Pandalus annulicornis.	Praniza cerina.
Hippolyte Fabricii.	Cerapus rubricornis.	Balanus porcatus, etc.
H. aculeata.		

Several of these occurred also in the previous lists, but are repeated here to show more fully the peculiar character of the fauna of these rough ledges. We ascertained that the cod-fish caught here feed chiefly on these crustacea, their stomachs often being filled with the crabs, shrimps, and smaller species named above, together with more or less numerous Mollusca, Holothurians, Ophiurans, etc. The *Ophiopholis aculeata* was a common and important part of their diet, and several specimens of a large *Thyonidium* were taken from the stomach of a cod, at this place, though we did not dredge it at all, either here or elsewhere.

Among the other species that occurred on the Cod Ledges, but not in the localities previously described, are the following:

Pycnogonids.

Phoxichilidium femoratum.	Nymphon, sp.

Annelids.

Eunoë Œrstedii.	Euphrosyne borealis.	Spirorbis quadrangularis.
Lepidonotus squamatus.	Amphitrite cirrata.	Vermilia serrula.

Gastropods.

Trophon scalariformis.	Trachydermon ruber Carp.	Tonicella marmorea Carp.
Menestho albula.		

Bryozoa.

Alcyonidium, red sp.	Tubulipora patina.	Lepralia, several sp.

Acalephs.

Lucernaria quadricornis.	Sertularia pumila?	Halecium muricatum.
Obelia geniculata.	Sertularella polyzonias.	Tubularia indivisa.

Also numerous sponges, not determined.

ALGÆ.

The following occurred in 12½ fathoms:

Agarum Turneri.
Delesseria sinuosa.
D. alata.
Calliblepharis ciliata.
Euthora cristata.
Ptilota serrata.
Callithamnion, sp.
Corallina officinalis.
Lithothamnion polymorphum.

Farther to the west, off the mouth of Casco Bay, and about two to three miles south of Half-way Rock, in 27 fathoms, we made another haul, very similar to the one in 33 fathoms, described above. The bottom was here composed of coarse sand and gravel, pebbles, small stones, and broken shells, with some mud. A large proportion of the species given in the list for the 33-fathom locality also occurred at this place, with many additional ones, among which were the following:

Crustacea.

Eupagurus Bernhardus.
Crangon vulgaris.
Hippolyte Fabricii.
Cumacea, two sp.
Ptilocheirus pinguis.
Anonyx, sp.
Ampelisca, sp. with red dorsal spots.
Ampelisca, small sp.
Anthura brachiata.

Annelids.

Nephthys, sp.
Ammochares, sp.
Nicomache, new sp., banded.
Pista cristata.
Terebellides Stroëmi.

Gastropods.

Bela decussata.
Scalaria Grœnlandica.
Natica clausa.
Lunatia immaculata.
Margarita obscura.
Cylichna alba.
Philine, sp.

Lamellibranchs.

Cryptodon Gouldii.
Cyclocardia Novangliæ.
Astarte quadrans.
Yoldia sapotilla.
Modiolaria nigra.

Echinoderms.

Hippasteria phrygiana, one large specimen.

In Casco Bay, among the islands, in moderately shallow water, there is great diversity in the character of the bottom, and a large amount of profitable dredging was done. Most of the species are decidedly boreal and arctic forms, which we had previously dredged in the Bay of Fundy, and farther north. The depth varied from 3 or 4 to about 30 fathoms. Some of the best localities on hard bottoms were found in Hussey Sound; off Cow Island; off the northern end of Peak's Island; off Witch Rock; off the Green Islands; off Whaleboat Island, in Broad Sound; and in the main ship-channel off Fort Preble, etc. In these localities the bottom was composed of small stones, and occasionally of rough rocks with broken shells, gravel, etc., overgrown by an abundance of coarse massive sponges, among which were several species of *Reniera*, *Halichondria*, *Suberites*, *Polymastia*, etc., together with more delicate species belonging to *Chalina*, *Isodictya*, etc.

The following are some of the more common and characteristic species dredged on the hard bottoms, in 8 to 30 fathoms:

Crustacea.

Cancer irroratus.
Hyas coarctatus.
H. araneus.
Eupagurus Bernhardus.
E. Kroyeri.
E. pubescens.
Crangon vulgaris.
Hippolyte spina.
H. Fabricii.

Hippolyte aculeata.
H. pusiola.
H. gibba.
H. Phippsii.
Pandalus annulicornis.
Mysis, sp.
Ptilocheirus pinguis.
Unciola irrorata.
Acanthozone cuspidata.

Paramphithoë? cataphractus.
Cerapus rubricornis.
Anonyx, sp.
Caprella, sp.
Idotea phosophorea Harger.
Balanus porcatus.
B. crenatus.

Annelids.

Lepidonotus squamatus.
Eunoë Œrstedii.
Harmothoë imbricata.
Phyllodoce catenula V.
Eulalia pistacia V.
Nereis pelagica.
Stephanosyllis picta, n. sp.
Procerea gracilis, new sp.
Autolytus cornutus.
Autolytus, sp.
Nothria conchylega.

Polydora, sp. (in shells).
Cirratulus cirratus.
Dodecacerea concharum.
Nicomache, new sp.
N. lumbricalis.
Trophonia aspera.
Tecturella flaccida.
Sternaspis fossor.
Cistenides granulatus.
Thelepus cincinnatus.
Scione lobata.
Amphitrite cirrata.

Polycirrus, phosporescent sp.
Myxicola Steenstrupii.
Potamilla oculifera (Leidy).
Sabella zonalis Stimp.
Chone, sp.
Spirorbis lucidus.
S. nautiloides?
S. quadrangularis St.
Vermilia serrula.
Filigrana implexa.
Phascolosoma cæmentarium.

Turbellaria.

Cosmocephala Stimpsoni V.
Nemertes affinis.
Leptoplana ellipsoides.

MOLLUSCA.

Gastropods.

Bela harpularia.
B. decussata.
B. turricula.
Admete viridula.
Trophon clathratus.
Buccinum undatum.
Neptunea decemcostata.
N. curta (Jeffrey's sp.), V.
Neptunella pygmæa V.
Tritia trivittata.
Astyris zonalis V. (dissimilis St.)
Trichotropis borealis.

Natica clausa.
Lunatia heros.
L. immaculata.
Crucibulum striatum.
Velutina zonata.
V. haliotoidea.
Lamellaria perspicua.
Menestho albula.
Scalaria Grœnlandica.
Margarita obscura.
M. Grœnlandica.
M. cinerea.

Calliostoma occidentale.
Lepeta cæca.
Cylichna alba.
Dendronotus arborescens.
Doris planulata.
Onchidoris pallida.
Doto coronata.
Tonicella marmorea Carp.
Trachydermon albus Carp.
Trachydermon ruber Carp.
Hanleia mendicaria Carp.
Amicula? Emersonii.

Lamellibranchs.

Saxicava arctica.
Mya arenaria (young).
Cyprina Islandica.
Cardium pinnulatum.
Cyclocardia borealis.

C. Novangliæ.
Astarte undata.
Crenella glandula.
Mytilus edulis.
Modiola modiolus.

Modiolaria nigra.
M. discors (lævigata).
M. corrugata.
Pecten Islandicus.
Anomia aculeata.

Ascidians.

Boltenia Bolteni.
Cynthia pyriformis.
C. echinata.
C. carnea.
Ascidiopsis complanatus.

Chelyosoma geometricum St.
Molgula pannosa.
M. retortiformis.
M. papillosa.

Amarœcium glabrum.
A. pallidum.
Lissoclinum, sp.
Leptoclinum albidum.
L. luteolum.

Brachiopods.

Terebratulina septentrionalis.

Bryozoa.

Idmonea pruinosa.
Crisia eburnea.
Tubulipora crates.
T. flabellaris.
Discoporella verrucosa.
Alcyonidium (red sp., on shells).
Caberea Ellisii.
Bugula Murrayana.
B. fastigiata.
Cellularia ternata.
Gemellaria loricata.
Membranipora pilosa.
M. lineata.
Lepralia Pallasiana.
Lepralia, several sp.
Discopora.
Cellepora scabra.
C. ramulosa.

RADIATA.

Echinoderms.

Pentacta frondosa.
P. calcarea.
Lophothuria Fabricii.
Psolus plantapus (young).
Thyonidium, sp.
Strongylocentrotus Dröbachiensis.
Asterias vulgaris.
A. littoralis (St.).
Cribrella sanguinolenta.
Solaster endeca (small).
Pteraster militaris (small).
Ophiopholis aculeata.
Ophioglypha robusta.
Amphipholis elegans.

Hydroids.

Obelia geniculata.
O. longissima.
Campanularia flexuosa.
C. volubilis.
C. verticillata.
C. angulata.
Clytia Johnstoni.
Calycella syringa.
Halecium muricatum.
Lafoëa fruticosa.
L. dumosa.
Antennularia antennina.
Sertularia argentea.
S. cupressina.
S. latiuscula.
Diphasia fallax.
Sertularella polyzonias.
S. tricuspidata.
Hydrallmania falcata.
Thamnocnida tenella.
Eudendrium tenue.
E. ramosum.
Hydractinia polyclina.

Polyps.

Metridium marginatum.
Urticina crassicornis.
Alcyonium carneum.

Sponges.

Grantia ciliata.
Polymastia robusta? Bowerbank.
P. ———, new sp.
Tethya hispida (Bowerb.).
Halichondria, sp.
H. pannosa.
Reniera, several sp.
Suberites, sp.
Cliona, sp.
Isodictya, sp.
I. lobata (Esper sp.).
I. infundibuliformis.
Chalina oculata.

Besides the species enumerated above, there were many others, that have not yet been identified. Many that occurred less frequently on the hard bottoms than on sandy or muddy ones, have also been omitted from the list.

Very few genuine sandy bottoms were met with, and these were generally of small extent, so that the sand was nearly always mixed with gravel, pebbles, or mud, when brought up in the dredge, and there was, necessarily, a corresponding mixture of the animals inhabiting these different kinds of bottom. Most of the species found on such bottoms are included in the preceding list. A number of species occurred, however, on sandy bottoms more frequently, or in greater abundance, than elsewhere. Among these were the following:

Crangon vulgaris, *Unciola irrorata*, *Anonyx*, sp., *Epelys montosus* Harger, *Praxilla*, sp., *Clymenella torquata* V., *Cistenides granulatus*, *Tetrastemma*, sp., *Ophionemertes agilis* V., new gen. and sp.,* *Lunatia heros, Menestho albula, Utriculus pertenuis, Lyonsia hyalina, L. arenata, Astarte castanea, A. quadrans, Cyprina Islandica, Echinarachnius parma.*

Muddy bottoms of various grades, and at all depths to 30 fathoms, were frequent in Casco Bay, especially in the sheltered coves and channels among the islands, and in the several branches or fiords into which the northeastern portion of the bay is divided. Among the species dredged on muddy bottoms were the following:

Pycnogonids.

Nymphon, sp.	Pallene, sp.	Phoxichilidium femoratum.

Crustacea.

Hyas coarctatus.	Mysis Americanus Smith.	Phoxus Kroyeri.
Eupagurus Kroyeri.	M. stenolepis Smith.	Corophium cylindricum.
E. pubescens.	Diastylis sculpta.	Pontoporeia, sp.
E. Bernhardus.	D. quadrispinosa.	Haploops, sp.
Crangon vulgaris.	Eudorella hispida.	Ampelisca, with red spots.
Pandalus annulicornis.	Unciola irrorata.	Anonyx, sp.
Hippolyte Gaimardii.	Cerapus rubricornis.	Orchomene, sp.
H. pusiola.	Ptilocheirus pinguis.	Idotea phosphorea Harger.
H. Fabricii.	Byblis Gaimardii.	Epelys montosus Harger.

Annelids.

Aphrodite aculeata.	Rhynchobolus albus.	Cistenides granulatus.
Harmothoë imbricata.	Polydora, sp., in shells.	C. Gouldii V.
Pholoë minuta.	Scolecolepis, sp.	Ampharete gracilis.
Nephthys, sp.	Anthostoma acutum V.	Amphicteis Gunneri.
N. ingens St.	Trophonia aspera V.	Melinna cristata.
Phyllodoce catenula V.	Ammotrypane fimbriata V.	Amphitrite brunnea V.
Phyllodoce, sp.	Ophelia, sp.	A. cirrata.
Eulalia pistacia V.	Sternaspis fossor.	Polycirrus, sp.
Eteone pusilla.	Nicomache, sp.	Chone, sp.
Nereis pelagica.	Nicomache lumbricalis.	Euchone elegans V.
Ninoë nigripes V.	Maldane Sarsii.	Chætoderma nitidulum.
Lumbriconereis, slender sp.	Praxilla, sp.	Phascolosoma cæmentarium.
L. fragilis.	Ammochares, sp.	
Goniada maculata.	Arenia, sp.	

Turbellaria.

Cosmocephala, orange sp.	Tetrastemma, sp.	Meckelia lurida V.
C. Stimpsoni V.	T. vittata V., new sp.†	Leptoplana ellipsoides.
Ophionemertes agilis V.		

* *Ophionemertes agilis* V.

Allied to *Tetrastemma.* Body slender, slightly depressed, with the sides well rounded, thickest in the middle, tapering gradually to the slender, obtuse posterior end; head somewhat separate from and wider than the anterior part of the body, changeable in form, often oval, sometimes sub-triangular, generally longer than broad, narrowed anteriorly, obtuse or slightly emarginate, with a terminal orifice. Eyes numerous, forming a long, crowded lateral row or group along each side of the head; the rows are simple and converge anteriorly, posteriorly they become broad and double. Back of the eyes there is a curved transverse groove or furrow, crossing the back of the head. No lateral fossæ observed. Color pale ochre-yellow; the intestine slightly reddish; the internal lateral organs lighter yellow, giving a reticulated appearance to the sides. Length 25^{mm} to 40^{mm}; $1{\cdot}5^{mm}$ to 2^{mm} in diameter.

Casco Bay, 20 to 65 fathoms; Bay of Fundy, 40 to 90 fathoms.

† *Tetrastemma vittata* V.

Body short and stout, obtuse at both ends, well rounded, little depressed; head

Gastropods.

Bela harpularia.	L. immaculata.	Turritella erosa.
B. turricula.	Velutina haliotoidea	Margarita obscura.
B. pleurotomaria.	Trichotropis borealis.	M. cinerea.
Buccinum undatum (young).	Rissoa carinata.	Utriculus pertenuis.
Neptunella pygmæa.	R. exarata.	Cylichna alba.
Tritia trivittata.	R. (?) eburnea.	Philine quadrata.
Lunatia heros, var.	Scalaria Grœnlandica.	Entalis striolata.

Lamellibranchs.

Zirphæa crispata (in wood).	Serripes Grœnlandicus.	Y. thraciformis.
Mya arenaria (young).	Lucina filosa.	Y. obesa.
Saxicava arctica.	Cryptodon Gouldii.	Nucula tenuis.
Lyonsia hyalina.	Solenomya velum.	N. delphinodonta.
Thracia Conradi.	Cyclocardia borealis.	N. proxima.
T. myopsis.	C. Novangliæ.	Crenella glandula.
Eusatella Americana.	Astarte lens.	C. decussata.
Macoma sabulosa.	A. undata.	Modiolaria nigra.
Callista convexa.	Leda tenuisulcata.	M. discors (lævigata).
Cyprina Islandica.	Yoldia sapotilla.	M. corrugata.
Cardium pinnulatum.	Y. myalis.	Mytilus edulis.
C. Islandicum.	Y. limatula.	Pecten tenuicostatus.

Ascidians.

Molgula pannosa.	Eugyra pilularis.

Echinoderms.

Asterias vulgaris.	Ophioglypha Sarsii.	Ophiopholis aculeata.
Ctenodiscus crispatus.	O. robusta.	

Hydroids.

Corymorpha pendula.	Sertularia argentea (on shells).	Sertularella tricuspidata (on shells).
Hydractinia polyclina.		

Polyps.

Metridium marginatum (on shells).	Edwardsia farinacea V.	Cerianthus borealis V.
	E. sipunculoides.	

not separate from body, obtusely rounded. Eyes four, small and not very distinct, the two pairs widely separate, the anterior ones near the anterior end, and nearer together than the others. A well-marked transverse groove or fold is situated between the two pairs of eyes, and extends around to the ventral side; proboscis-orifice terminal. Color of body dark olive-green, greenish brown, or greenish black, often with a light longitudinal dorsal stripe; head greenish, marked with six longitudinal white stripes or vittæ, which radiate from the terminal orifice, and extend backward to the transverse furrow, which is bordered by a transverse band of white, often forming a whitish ring round the head; two of the vittæ are dorsal; two ventral; and one lateral on each side; a less distinct median ventral one is sometimes visible. Length, 25^{mm} to 40^{mm}; diameter, 4^{mm} to 7^{mm}.

Errata for No. XXV.

Page 439, line 14, for *Krogeri*, read *Kroyeri;* line 16, for *Nychia cirrosa*, read *Eunoë Œrstedii;* line 24, for *lucida*, read *nitidulum.*

Page 440, line 4, for *sopotilla*, read *sapotilla;* line 9, for *solidula*, read *solida;* last line of foot-note, for 1870, read 1780.

ART. X.—*Note on Fossil Woods from British Columbia, collected by Mr. Richardson;* by Principal DAWSON, LL.D., F.R.S.*

IN my note of last year on the plants collected by Mr. Richardson in 1872, I referred to specimens of fossil coniferous wood from the coal-field of Nanaimo, Vancouver Island. Mr. Richardson's collections of 1873 include a much larger number of specimens of fossil wood from the Queen Charlotte Islands, Norris Island and Hornby Island, all of them apparently from Mesozoic rocks, and many of them associated with characteristic marine shells of Cretaceous or Jurassic genera. They are principally drift trunks, though probably from not very distant land, and some of the specimens have been bored by Teredine mollusks.

Mr. Weston, the lapidary of the Survey, has prepared upwards of a hundred excellent slices of these fossils, all of which I have carefully examined, with the following general results:—

I. CONIFEROUS WOODS.—These are by much the most abundant in the collection, ranging in age from the probably Lower Cretaceous or Jurassic beds of Queen Charlotte Island to the probably Middle and Upper Cretaceous of Vancouver Island and Hornby Island. They may all be referred to the genera *Cupressoxylon* and *Taxoxylon*, or in other words are allied to the modern Cypresses and Yews, trees which range with very little modification of type from the Mesozoic to the modern period.

Cupressoxylon.—This genus is characterized by distinct concentric rings of growth, round discs or bordered pores on the walls of the fibers in one or two series, resin cells (which are, however, often very obscure in the fossil specimens), and simple medullary rays.

One of the most common woods of this type in the collections from the Queen Charlotte Islands, Vancouver Island and Hornby Island, is of the same character with the wood of the modern *Sequoia gigantea* of California, and probably belonged to an allied tree.

Another from Vancouver Island, with two rows of pores on each fiber, is scarcely distinguishable from specimens of the ordinary California Redwood, in the collection of Prof. Gray, of Cambridge, who has kindly given me specimens for comparison.

Another species, differing from the above in its very short medullary rays, and having one row of pores on the walls of the fibers, occurs at Queen Charlotte and Vancouver Islands.

* From proof received in advance of the publication of the article in the Report of the Geological Survey of Canada for 1873.

Two others, with well developed resin cells, and one row of pores on the fibers, are found at Vancouver Island alone.

I do not think it necessary to attach specific names to these trees, at least until I can compare them with more complete series of woods from the west coast. It is sufficient to know that they indicate several species of Cypress-like trees not very dissimilar from those at present existing in the region.

Taxoxylon.—This genus is characterized by consecutive lines of growth, by wood-cells with spiral fibers, in addition to the bordered pores, and by simple medullary rays.

There appear to be in the collection three species of this genus, two from Vancouver Island and one from the Queen Charlotte Islands. They have the characters of modern taxine woods, modified a little probably by the long maceration in water which they have sustained. Many of the modern taxine trees are remarkable for the toughness of their fiber, arising apparently from a less firm lateral adhesion than usual of the woody fibers to each other, and, also, perhaps, from the pecularities of their ligneous lining. This laxity of the tissue becomes exaggerated in the water-soaked fossil specimens, so that in cross section the wood-cells appear as if round within. and separated by intercellular spaces, the appearances recalling those in the Devonian *Prototaxites*, which, however, presents them in a still more exaggerated form. The study of these more modern taxine trees has served to confirm my belief in the interpretation I have given of the Devonian prototype of *Taxineæ*.

II. Angiospermous Exogens.—Wood of this class is not so abundant in the collection as coniferous wood ; but it is of much interest as exhibiting the existence in the Cretaceous period of the same modifications of wood which exist at present, and as corresponding with the leaves of exogenous trees found in the coal formation of Nanaimo.

Quercus.—Two species of oak occur in the collection. One is from the Upper Cretaceous shale of Hornby Island. The other is from the Cretaceous coal-field of Vancouver Island, at Trent River below the Falls, or according to Mr. Richardson's sections, about 3,000 feet lower than the Hornby Island beds.

Quercus, No. 1, Hornby Island.—This has very large medullary rays of many series of cells, the ducts small, uniformly scattered and annular. Of the species with which I have means of comparison, it most nearly resembles *Q. ilex* of the south of Europe, but has larger medullary rays. The specimen is a fragment of a decorticated stem about six inches in diameter, and to the naked eye has much the appearance of a blackened fragment of the wood of *Q. suber*.

Quercus, No. 2, Vancouver Island.—The medullary rays are narrower than in the last, and more dense. The ducts are more collected in the vicinity of the rings of growth, and are apparently dotted. The specimen is a fragment of wood in a nodule.

Both the above species have more resemblance to European oaks than to those of Eastern America; and unfortunately I have not yet been able to procure specimens of the wood of the modern oaks of British Columbia for comparison.

Betula —One specimen from Vancouver Island, a fragment of a stem about three inches in diameter, and with a very smooth external surface, presents the characters of Birch wood, and is not very dissimilar from the modern *Betula papyracea.* It has clustered ducts, evenly disposed and dotted on the walls, and thin-walled wood cells. The medullary rays are narrow and frequent, of about three rows of cells.

Populus.—This is also a specimen from Vancouver Island. It is a small knot or base of a branch, imbedded in a nodule. Its structure is not dissimilar from that of *Populus balsamifera.* The wood has infrequent scattered ducts and delicate medullary rays of one series of cells. Its growth-rings are distinct.

These woods afford an additional evidence of the fact already commented on by Lesquereux and Newberry, that in the Cretaceous period the generic types of American trees were as well marked as at present; and they are further curious in connection with the occurrence of workable coal, which must have been accumulated by plants thus modern in aspect.

CYCADEÆ.—*Cycadeocarpus* (Dioonites) *Columbianus*, n. sp.—This is a large and beautiful fruit, showing its internal structure, and associated with fragments of petioles and leaves, which, from the similarity of their tissues, I regard as probably belonging to the same species. I shall, therefore, describe under this head these different organs, in the hope that future discoveries may make good my judgment as to their specific identity.

(1) *Fruit.*—Broadly ovate or nearly oval. Surface smooth, but with traces of indented longitudinal bands. Apex rounded or obtusely pointed. Base showing a broad surface of attachment, with a ring of scars of about twenty-two fibrous bundles which probably passed upward on the outer rind. Length of largest specimen, 5·25 centim. Largest transverse diameter, 4·5 centim. Length of a smaller specimen, 4 centim. Largest traverse diameter, 4·25 centim. This smaller specimen has probably been vertically compressed.

When sliced, it shows an epicarp (or testa) of large and rather thick-walled hexagonal cells, without any fibers or vessels. Within this is a narrow structureless ring filled with calcite, and probably a result of shrinkage. This encloses the endocarp (or tegmen), which is thin and composed of fine cells, and apparently lined with a dense membrane. The nucleus, which was large, has entirely disappeared, its place being occupied by structureless calcite.

(2) *Petiole.*—This is a slightly flattened cylinder, two centimeters in diameter. Externally it has a thin bark of small elongated cells, arranged in little groups in a radial manner. Within this is a continuous tissue of hexagonal cells, interspersed with what seem to be gum or proper juice-cells, darker in color, and each enclosed in a sheath of smaller cells. This cellular substance is traversed by about 45 bundles of fibers, presenting in the cross section a somewhat Hippocrepian arrangement. Thirty of these bundles, in the cross section, form a circle a little within the bark—the larger bundles being at the lower side. At the upper side is one bundle larger than those in its vicinity and of a round form, and from either side of this the remaining bundles form a deep loop extending considerably beyond the center of the petiole. Each bundle consists of fine fibers radially arranged and coarser outside, and with these are from one to five lacunæ, which in the longitudinal section seem to be oval intercellular spaces. The fibers show in places a delicate transverse or pseudo scalariform marking similar to that in modern Cycads.

(3) *Leaves.*—These have the structure well preserved, though in a fragmentary condition. The fragments are parallel-sided, about half an inch wide, thick, and traversed by strongly developed parallel fibrous bundles, imbedded in delicate cellular tissue. Each bundle is enclosed in a sheath of dense cells, and some of the fibers show the barred structure already mentioned. Between the principal bundles are secondary nerves, each consisting of a single, perhaps laticiferous, vessel. The epidermis is composed of dense irregular cells. The structures are similar on the whole to those in the pinnules of the leaf of *Dioon*, though they also remind an observer of the leaves of *Yucca gloriosa.*

On the supposition that the above described organs belong to one and the same plant, it had no doubt a thick though perhaps short stem, large compound leaves, having their divisions thick and rigid, with parallel veins, fruits or large naked seeds, supported on massive peduncles, or sessile on a common peduncle, and when mature furnished with a thick and probably dry cellular coat. No true vascular structures are apparent in any of the specimens. These characters would point to the Cycads; and, perhaps, nothing of this kind more nearly approaches to the fossil than the modern *Dioon edule* of Mexico, of which this may be regarded as a Cretaceous predecessor. It may, I think, very properly be placed in the genus *Dioonites*, created to receive certain fossil cycadeous leaves from the Mesozoic of Europe. The fruit, if described by itself, would go into the genus *Cycadeocarpus.*

The specimens are from the Lower Cretaceous or Jurassic of Skidegate Channel, Queen Charlotte Islands.

Filices.—*Pecopteris.*—The shales of Hornby Island, along with many obscure vegetable fragments, contain pinnæ of a fern approaching in outline to *Pecopteris Phillipsii* of the English Oolite, though of much smaller size. As its venation is not preserved, I think it best not to give it a name.

The fossils from the Queen Charlotte Islands, consisting entirely of Pines and Cycads, while decidedly Mesozoic, would indicate a somewhat older stage than the others, say the Jurassic or Lower Cretaceous.

The fossils from the coal-field of Vancouver Island, embracing, in addition to coniferous trees, both wood and leaves of several species of Angiospermous Exogens, coincide with those of the Cretaceous of other parts of America, for example, of Nebraska.

The fossils from Hornby Island, in shales believed to overlie those of Vancouver Island, are also Cretaceous; and there is nothing to preclude their belonging to the upper part of that system.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Vapor-density of Potassium.*—The position of the alkali-metals in the modern chemistry scale of equivalence rests upon the assumption that the molecule of these metals is made up of but two atoms; and hence that its molecular weight, which of course is twice its density, is double its atomic weight. To test this question, Dewar and Dittmar have undertaken to determine the density of potassium-vapor experimentally. The great difficulties to be overcome are sufficiently obvious; but after several failures, the authors succeeded in devising the following practicable process: A cylindrical iron bottle of 200 cc. capacity, and sufficiently rigid to maintain its shape at a bright red heat, is made use of, a curved neck well ground in, and pierced with a canal 2 mm. diameter, being fitted to it. For a bath, 20 kilos. of zinc are placed in a plumbago crucible in a forge fire, by which the zinc can be brought to the boiling point. The bottle is first deoxidized interiorly by a current of dry hydrogen at a red heat; after partial cooling, 200 grams of mercury are introduced, and the bottle is placed in the red-hot zinc. After three-fourths of the mercury has distilled off, the neck is withdrawn, and an iron test-tube containing 4 or 5 grams of potassium is dropped in. The neck is then replaced, the bottle is wholly immersed in the zinc, now brought to boiling, the neck being kept clear. The potassium

volatilizes and issues in jets of vapor into the air. As soon as this distillation ceases, the nozzle is closed by a ground-in wire, and plunged beneath the surface of mercury in a test-tube. The bottle is removed from the zinc and allowed to cool. As soon as it can be handled, it is placed in recently boiled water, the wire plug is removed, and the hydrogen formed by the action of the potassium on the water pumped out by a Sprengel pump and carefully measured. From these data the vapor-density may be calculated. And, although the method needs perfecting and there are several corrections needed, the authors are confident that the vapor-density of potassium cannot be more than 45 times that of hydrogen. As therefore the question is between 39 and 78, the fact that it cannot exceed 45 makes it certain that the molecule of potassium in vapor consists of two atoms.—*Proc. Roy. Soc.*, xxi, 143, April, 1873. G. F. B.

2. *On the Hydrocarbons produced by the solution of cast-iron in acids.*—In the November number of this Journal, Mr. F. H. Williams communicated some results of his examination of the hydrocarbons evolved on treating cast-iron with acids. We have received a letter recently from Mr. H. C. Hahn, now of Wyandotte, Michigan, calling attention to the fact that he made a similar investigation in 1864, the results of which were published in Liebig's Annalen. The portions of the evolved gases which were absorbable by fuming sulphuric acid or bromine—amounting in the case of white iron to 1·26–1·6, and in the case of gray iron to 0·36–0·28 per cent by volume—consisted of ethylene, propylene, butylene, amylene and caproylene, as was proved by the boiling points, the composition and the other properties of their bromides. Acetylene was not detected. The gases not thus absorbable, which were very small in quantity, gave no satisfactory results on eudiometrical analysis. Undoubtedly marsh gas was present. The liquid products, given in greater quantity by white than by gray iron, proved to be a mixture of the homologues of ethylene, boiling between 110° and 290°. There separated out also, from the ferrous sulphate solution, on treatment with water, a disagreeably smelling oil, which, by access of air or by treatment with chlorine water, became brown and resinous. The dry residue of the iron, insoluble in acids, gave to alcohol and ether a yellow color, and there was dissolved an acid substance precipitable by lead acetate. A sulphur product was also observed. It is a noteworthy fact that in Mr. Williams's experiments in which strong hydrochloric acid was used to dissolve the iron, the hydrocarbons were evolved in the form of chlorides; while in Mr. Hahn's, in which the acid was diluted with two parts of water, they were evolved uncombined.—*Ann. Chem. Pharm.*, cxxix, 57, 1864. G. F. B.

3. *On the Optical properties of Cymene from different sources.*—Gladstone has submitted to examination eight specimens of cymene obtained by Wright from widely different sources. The following are the results obtained:

No.	Source of Cymene.	Temp.	Sp. gr.	Refractive index.		
				A.	D.	H.
1	Cumin oil,	16°	0·8569	1·4819	1·4901	1·5173
2	Preexisting in turpentine,	16°	0·8553	1·4775	1·4851	1·5111
3	" " myristicene,	16°	0·8630	1·4799	1·4876	1·5145
4	From hesperidene dibromide, I,	13°	0·8605	1·4835	1·4916	1·5196
5	" " " II,	15·5°	0·8638	1·4834	1·4909	1·5187
6	" camphor, by PCl_5,	16°	0·8621	1·4852	1·4935	1·5218
7	" myristicol, by $ZnCl_2$,	14·5°	0·8424	1·4706	1·4776	1·5021
8	" " " PCl_5,	13°	0·8620	1·4815	1·4888	1·5172

From these experimental data, the following values may be calculated; the specific refractive energy and refraction-equivalent being deduced for the line A, and the specific dispersion being the difference between the specific refractive energies for A and H:

Number.	Specific Refractive energy for A.	Specific Dispersion.	Refraction-equivalent for A.
1	0·5623	0·0414	75·3
2	0·5581	0·0393	74·7
3	0·5561	0·0401	74·5
4	0·5619	0·0419	75·3
5	0·5596	0·0409	75·0
6	0·5628	0·0424	75·4
7	0.5586	0·0374	74·8
8	0·5596	0·0404	75·0

These results Gladstone regards as practically identical and as giving the mean optical data for cymene, as follows:—

Specific refractive energy, ... 0·5599
Specific dispersion, ... 0·0405
Refraction-equivalent, ... 75·0

In 1870, Gladstone called attention to the fact that those aromatic hydrocarbons and their derivatives which had been optically examined gave a refraction-equivalent higher by six or eight than the theoretical number. Since all these bodies have a high dispersive power, this increased retardation was supposed to be due to something analogous to a change in equivalence; i. e., to the fact that the whole of the carbon atoms were not combined with two of hydrogen or one of oxygen. As cymene is an aromatic hydrocarbon, the question arises: can it be prepared from bodies not belonging in this group; and if so prepared, will it retard light similarly? The production of cymene from camphor, from hesperidene and from myristicol by Wright, answers the first part of this question in the affirmative; the above tables of Gladstone, the second, likewise affirmatively. None of these cymenes rotate a polarized ray; but the author thinks this of slight moment, believing this property to be dependent not upon composition, but upon peculiar internal structure. Refractive phenomena, however, are profoundly connected with the ultimate composition of bodies; hence, from the above results it may be inferred that in cymene its super-retardant power arises from the fact that some of the carbon atoms are combined with less than two hydrogen atoms or their equivalent.—*J. Chem. Soc.*, II, xi, 970, Oct., 1873.

G. F. B.

4. *On the Constitution of the Allyl compounds.*—The generally received formula for allyl alcohol is CH_2=:=CH–·–CH_2OH; and hence many chemists assign to crotonic acid derived from it, the similar formula

CH_2=:=CH–.–CH_2–·–COOH.

But from other and independent evidence, Kekulé has assigned to crotonic acid the formula

CH_3–·–CH=:=CH–.–COOH.

If this latter formula be the correct one, then in the conversion of allyl alcohol into crotonic acid, a change in the position of the double bond uniting two of the carbon atoms takes place. KEKULÉ and RINNE have sought to ascertain by experiment at what stage of the conversion this shifting of the bonds was effected. The allyl alcohol—prepared from glycerin by means of oxalic acid—was converted into allyl iodide. That no change in structure occurred at this point was proved by converting the iodide into oxalate and from this regenerating the alcohol; it was found to be absolutely identical with that originally taken. Allyl cyanide was then carefully prepared from the iodide, and the three products, the alcohol, iodide and cyanide, submitted to oxidation. If allyl compounds have the formula CH_3–·–CH=:=CHR, oxidation both by chromic and by nitric acids must yield acetic and carbonic acids, and in the case of the cyanide, nitric acid must produce oxalic acid. If, however, this formula is CH_2=:=CH-·-CH_2R, no acetic acid will be produced, but formic (or carbonic) and oxalic acids, and from the cyanide, malonic acid or its decomposition products. On oxidizing allyl alcohol with chromic acid, carbonic gas is evolved, and formic acid, but no acetic, is produced. Nitric acid produces carbonic and oxalic but no acetic acid. Precisely the same oxidation products were yielded by the iodide. The cyanide, however, when oxidized by chromic acid, gave an abundance of acetic acid, and by nitric acid, oxalic acid in addition. These experiments prove that the alcohol and the iodide possess the same structure, corresponding to the second of the above formulas; while the cyanide is the true nitrile of crotonic acid, possessing, like this acid, the structure shown in the first formula above given. A structural change does therefore take place when the iodide becomes cyanide, and crotonic acid has the formula assigned to it originally by Kekulé.—*Ber. Berl. Chem. Ges.*, vi, 386, April.

G. F. B.

5. *On Brazilin and Resorcin.*—EMILE KOPP has subjected brazilin to a new investigation. The material was obtained from the dark brownish-red crusts which are formed in considerable quantity in the preparation of Brazil-wood extract, and which consist of brazilin and a calcium-brazilin lake. These crusts are rubbed up with water containing 5 per cent hydrochloric acid, the residue washed, and then boiled with water containing 10 to

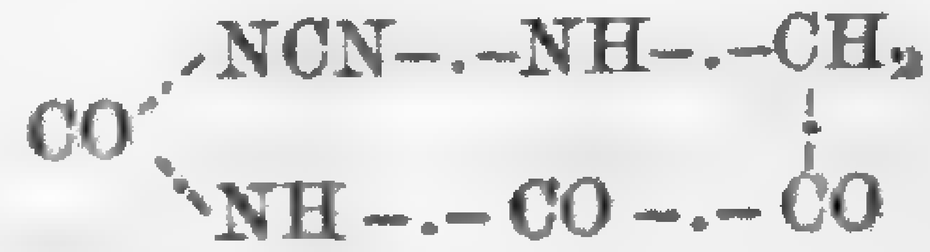
15 per cent of alcohol. On cooling, the filtrate deposits beautiful yellowish crystals of brazilin, which are pure after re-crystallization from hot water. The wash-waters and mother-liquors on evaporation to dryness with a little chalk, yield resorcin on dry distillation. Pure brazilin is colorless and yields colorless solutions, which scarcely color mordanted cotton. On standing, however, the solutions become yellow and finally reddish-yellow, acquiring a coloring power; but it is not easy to obtain crystallized brazilin from them afterward. In dilute soda solution brazilin dissolves with a splendid carmine color; this solution heated with zinc dust in a sealed tube, is reduced and becomes colorless; it is then a most delicate test for oxygen, the smallest trace of air developing an intense carmine-red. Submitted to dry distillation, brazilin affords a nearly colorless liquid distillate, which, filtered through a wet filter and concentrated on the water-bath, deposits on cooling large nearly colorless crystals of resorcin. The author recommends this method therefore, as the best by which to prepare this substance. The crystals melt at 98°–99°, and distil unchanged at 266°–267°. When treated with fuming sulphuric acid in excess, resorcin gives a characteristic reaction, being dissolved at first with an orange-yellow color, which becomes darker, greenish-blue, green, and in 20 or 30 minutes, a most magnificent blue, which, warmed to 90°–100°, becomes a splendid purple. On dilution with water the color changes to yellowish-red, which becomes deep carmine-red on adding sodium hydrate, the solution showing strong fluorescence. Kopp assigns to brazilin the formula $C_{22}H_{18}O_7$; and supposes the following relation to exist between brazilin, hematoxylin and resorcin:—

$$\underset{\text{Brazilin.}}{C_{22}H_{18}O_7} + H_2O = \underset{\text{Hematoxylin.}}{C_{16}H_{14}O_6} + \underset{\text{Resorcin.}}{C_6H_6O_2}$$

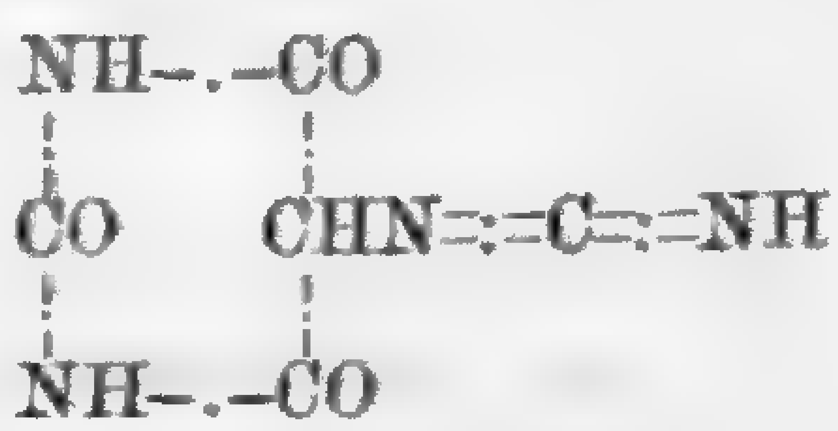
—*Ber. Berl. Chem. Ges.*, vi, 446, April, 1873. G. F. B.

6. *On the synthesis of an Isomer of Uric acid.*—Mulder has re-investigated the constitution of uric acid. The four most probable formulas for this constitution are the following:—

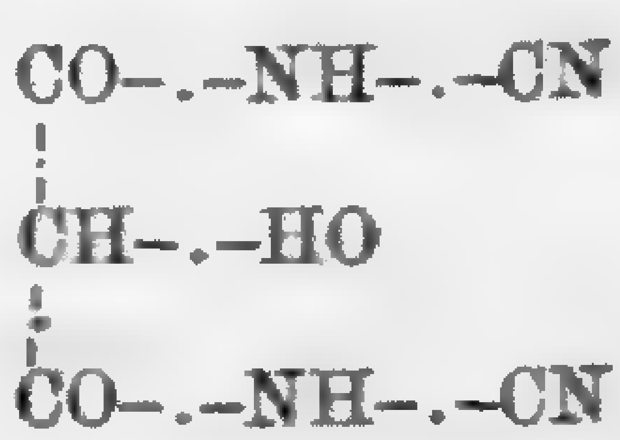
A. Strecker's.



B. Erlenmeyer's.



C. Kolbe's. (Oxymaloncyanamide).



D. Mulder's (Dialurcyanamide).

The decomposition of uric acid into dialuric acid—which passes into alloxantin and alloxan by oxidation—by the action of nitric acid, makes formulas B and D the most probable. Indeed, if cyanamide is NH_2-·-CN, dialurcyanamide is represented by D, as above; but if cyanamide be really carbodiimide, NH=:-C-:=NH, then the same substance has the constitution given in B. Mulder has attempted the synthesis of uric acid on the supposition that its constitution was represented by one of these two formulas. Starting from the well-known fact that alloxantin, by the action of ammonia, gives dialuramide and alloxan, he assumed that by the action of cyanamide, it would give dialurcyanamide and alloxan, according to the empirical equation:

$$C_8H_4N_4O_7 + H_2N.CN = C_5H_4N_4O_3 + C_4H_2N_2O_4.$$

Cyanamide was carefully prepared by the action of ammonia gas upon an etherial solution of cyanogen bromide. Alloxantin was prepared by reducing alloxan with H_2S. Two grams alloxantin were dissolved in as little water as possible and one gram cyanamide, also dissolved in a minimum quantity of water, was added and the two boiled together. Presently a heavy pulverulent precipitate formed, recalling uric acid, and weighing 0·7 grams. It afforded on analysis the formula of uric acid, $C_5H_4N_4O_3$. Alloxan was detected in the filtrate, showing that the above reaction took place. Two grams of this powder were dissolved in potassium hydrate. On adding hydrochloric acid a gelatinous precipitate, resembling that of uric acid, was produced. But unlike this it did not become crystalline on adding an excess of acid and warming. The potash solution gives a black precipitate with silver nitrate, like uric acid. Though also almost insoluble in water, it possesses like uric acid a weak acid reaction. Mulder proposes provisionally the name *isouric acid* for the new substance, and suggests that in true uric acid the hydrogen atom now in the lateral chain may be united to CH, thus:

```
   ,NH-.-CO-.-CH2
CO<            :
   `NH-.-CO-.-NCN
```

—*Ber. Berl. Chem. Ges.*, vi, 1233, Nov., 1873. G. F. B.

7. *On the Condensation of Gases and Liquids by Wood-charcoal. Thermic phenomena produced on the contact of Liquids and Charcoal. Liquefaction of the condensed gases;* by M. Melsens.—Absorption of chlorine by wood-charcoal may go on until it represents a weight of chlorine equal to that of the charcoal; consequently the condensing force of the latter may serve to realize the liquefaction of the non-permanent gases.

Charcoal put into a tube similar to Faraday's Λ-shaped tube is saturated with chlorine. The two extremities of this siphon tube being then sealed at the lamp, if the long branch of the tube be heated in a water-bath of boiling water, and the short branch be dipped into a freezing-mixture, a considerable quantity of chlorine leaves the charcoal and resumes the gaseous state; and under the influence of the pressure developed, this gas liquefies in the cooled short branch.

I have in this way obtained several cubic centimeters of pure liquid chlorine. On taking the tube out of the bath, the liquid chlorine commences spontaneous ebullition, and again condenses on the charcoal, while the short branch becomes covered with a frost. This succession of phenomena can be reproduced, so to say, indefinitely; and the experiments, easy to perform at public lectures, permit the audience to observe the various phases.

Although I can only consider my experiments a trial, I have extended them to the liquefaction of several gases absorbed by the charcoal when cold and disengaged by a temperature not rising above 100° C.:—chlorine, ammonia, sulphurous, hydrosulphuric and hydrobromic acids, chloride of ethyle and cyanogen. The liquefaction of each of these gases can be demonstrated in lectures when explaining the history of those bodies.

Reflecting on the feeble thermic effects ascertained by Pouillet when pulverulent mineral matters are soaked with water, oil, alcohol or acetic ether, and on the somewhat greater effects exhibited when the same liquids are absorbed by organized substances, I asked myself if we could not succeed in ascertaining pronounced thermic effects by placing in contact with cellules of charcoal liquids which do not act upon it—water, alcohol, ordinary ether, sulphide of carbon and bromine.

The experiments exceeded my expectation. For example, with one part of charcoal and from seven to nine parts of liquid bromine, the rise of temperature exceeds 30° C., operating on only from five to ten grams of charcoal.

With charcoal well freed from gas, heated and cooled *in vacuo*, the heating due to the imbibition of bromine would doubtless be much more considerable.

The volatile liquids condensed in the pores of the charcoal (bromine, cyanhydric acid, sulphide of carbon, ordinary ether and alcohol) are not expelled, or only partially, by a temperature of 100° C. at the ordinary pressure. I made the experiment with a Faraday tube, operating as described for the liquefaction of the gases. A tube filled with charcoal saturated with alcohol does not permit any to distil at 100°.

[The tubes were exhibited to the Academy; and with them the principal experiments (the liquefaction of chlorine, cyanogen, &c.) have been repeated in the laboratory of the École Centrale. The condensation of liquid bromine by charcoal, effected upon a few grams, gave rise to a brisk rise of temperature, the mixture passing in a few minutes from 20° to 45°.]—*Comptes Rendus de l'Académie des Sciences*, Oct. 6, 1873. *Phil. Mag.*, IV, lvi, 410.

8. *Rapidity of Detonation.*—Prof. ABEL and Mr. E. O. BROWN have during the past ten years conducted a series of experiments on gun-cotton or pyroxilin, which serve to show us how much we have still to learn of the properties of this material. Its energy of explosion varies with the way in which it is inflamed; thus, if

gently ignited by a spark, the cotton, in the form of yarn, smoulders slowly away; when set on fire by a flame, it burns up rapidly; if in the form of a charge it is ignited in a mine or fire-arm, it explodes like gunpowder similarly placed, while, lastly, if fired with great violence with a few grains of fulminate of mercury, it is detonated with as much force and with the same terrible effect as its instigator.

More recently, our investigators have succeeded in exploding gun-cotton to the best advantage, when damp; and in this state the explosion is every bit as violent as when the material is dry. This discovery is of the utmost importance, as when very wet, gun-cotton is not only non-explosive, but positively non-inflammable. In fact it would be as serviceable as a wet towel in extinguishing a fire. When placed in contact, however, with a cake of dry gun-cotton to start the action, and ignited by a little fulminate of mercury, it explodes with the utmost violence. Moreover, the amount of water makes no difference, for it has been found that, for submarine mines, compressed cakes enclosed in a fishing-net and thrown overboard, with a dry primer and a fulminate fuse, will explode with just as much energy as when confined in a water-tight steel case.

If a line of gun-cotton cakes, placed so as to touch each other, are detonated at one end, the explosion will travel with a velocity exceeding anything we are cognizant of, with the exception of light and electricity. In one experiment, forty-two feet of the material was fired, and the velocity measured for every six feet by a Noble's chronoscope. In this case the results were most uniform, for the velocity only varied from nineteen to twenty thousand feet per second.—*Nature*, p. 534, Oct., 1873. E. C. P.

9. *Heat generated by the absorption of hydrogen by platinum black.*—M. FAVRE claims that the hydrogen set free by electrolysis is *active*, and that in passing into the ordinary gaseous condition it sets free about 4600 units of heat. This heat not being transmissible to the circuit, he calls the class of phenomena to which this allotropic change of hydrogen belongs, *meta-electrolytic*.

The action of the platinum black on hydrogen differs from that of sheets of palladium. When the gas is introduced in successive amounts in contact with the platinum black, until the point of saturation is reached, the heat set free is not constant for equal volumes of gas absorbed, as is the case with palladium. Thus for one grain of active hydrogen set free by the electrolysis of sulphuric acid, and condensed by the palladium, the first experiment, gave 8,938 units of heat, and the seventeenth 9,167. For the condensation of common gaseous hydrogen, on the contrary, the amount of heat grew less and less, being 23,075 units in the first experiments and only 13,528 in the fourth. The hydrogen condensed by the palladium seems, therefore, to spread uniformly throughout the whole mass of the metal, forming with it a true alloy, while the hydrogen condensed by platinum black seems to distribute itself like carbonic acid or ammonia in wood-charcoal, that is, forming layers less and less dense, starting from the surface of the metal. Consider now what takes place when sulphuric acid is decomposed by a couple of zinc and palladium; and by a similar couple of zinc and platinum. In the first case, the hydrogen is absorbed directly by the palladium, and sets free 9,000 units of heat, which may be regarded as the expression of the heat due to the combination of hydrogen in the active and liquid condition with solid palladium, to form an alloy when the gas passes into the solid condition without ceasing to be active. It is no longer the same when hydrogen having the same origin is set free in the presence of platinum. In this case, the active hydrogen emerging from combination in the condition of a true explosive body, undergoes an allotropic modification and is transformed into ordinary hydrogen in the liquid condition. The amount of heat disengaged by this change is so great that the calorimeter shows about 4,600 units, notwithstanding the absorption of heat due to the passage of the hydrogen so formed from the liquid to the gaseous state.

About 20,700 units of heat are generated by the union of the hydrogen with platinum black, and adding this to the 4,600 given above, gives 25,300 as the amount which would be disengaged if the hydrogen did not undergo a transformation before its condensation by the platinum, at the surface of which it would cease to be in the active condition. The hydrogen, active and liquid, which disengages only 9,000 units of heat in uniting with the palladium, ought necessarily to remain in the active condition and to form with this metal a true explosive alloy capable of disengaging 14,000 units of heat by its decomposition.

Finally, the thermal phenomena accompanying the composition and decomposition of water are not so simple as we should at first believe. Starting with the constituent elements in their ordinary condition, the quantity of heat shown by the calorimeter is the algebraic sum of the numbers furnished by the following phenomena: 1st. Passage of the oxygen and hydrogen from their ordinary gaseous condition. 2d. Combination of these elements thus modified. 3d. Passage of the vapor of water to its liquid condition.—*Comptes Rendus*, 656, Sept. 22d, 1873. E. C. P.

10. *A new Thermo-Electric Battery.*—M. CLAMOND has constructed a new form of thermo-electric battery, which gives a nearly constant current as long as the temperature remains unchanged. Formerly, with Mr. Mure, he constructed batteries of galena; but they did not last, and, after some hours, or at most some days, the current diminished, and finally ceased entirely. An examination shows that the passage of the electric current finally decomposes the galena; hence a change takes place in the structure of the bars, their interior resistance increases, and the electro-motive force diminishes. Further, the galena decomposes in streaks, and consequently after some time unequal expansion takes place in the bar, causing it to crack, and thus shortly rendering it useless. In the new batteries these difficulties are completely overcome, the chemical and molecular condition of the bars remaining absolutely

the same. They have been tested for ten months by Mr. Michel, at the physical laboratory of the Sorbonne, and as a result it is found that their electro-motive force and resistance do not undergo the least change, as long as they are heated to a constant temperature.

When heated by a gas burner, they form a very convenient source of electricity for the laboratory, only requiring a match to put them in action, while, when constructed on a larger scale and heated by a coal-burning furnace, they form an excellent source of a powerful and constant current of electricity, for plating or other purposes.—*Les Mondes*, 231, Oct. 9th, 1873. E. C. P.

II. Geology and Natural History.

1. *Decomposition of Crystalline Rocks;* by T. Sterry Hunt.—Dr. T. Sterry Hunt gave some account of the crystalline rocks of the Blue Ridge and their decomposed condition, as seen by him at various points in the region to the southwest of Lynchburg, Va. They are principally gneisses with hornblendic and micaceous schists like those of the Montalban or White Mountain series, and are completely decomposed to a depth of fifty feet or more from the surface, being changed into an unctuous reddish brick-clay, in the midst of which the interbedded layers of quartz are seen retaining their original positions, and showing the highly inclined attitude of the strata. In the adit of a mine, where the rocks had been penetrated to a considerable distance, the coarsely feldspathic gneiss was found completely kaolinized, but free from the ferruginous coloring of the surface, while farther in, after passing through a partially decomposed portion, the hard, unchanged rocks were met with. A similar decomposition of the gneissic and granitic rocks in Brazil, extending to a depth of one hundred feet, has been well described by Hartt, and is known in many other regions. The speaker noticed the permeable nature of the surface soil thus formed of inclined clayey strata, which afford a natural subterranean drainage and prevent the accumulation of water in pools and lakes.

The nature of these chemical changes of the gneissic and hornblendic rocks was next considered. It consisted essentially in the removal, in the form of soluble carbonates, of the alkalies, lime and magnesia of the silicated minerals and the hydratation of the residues. The iron-oxide from these has also been in great part dissolved out by subsequent processes, and was the source of the immense deposits of hydrous iron ores which are found at the foot of the barrier range of the Blue Ridge throughout the Appalachian Valley.

The great antiquity of this chemical decomposition of the rocks was next alluded to. It was, in his opinion, effected at a time when a highly carbonated atmosphere and a climate very different from our own prevailed. That this decomposition had extended to the crystalline rocks to the northeastward he did not doubt; and he ascribed the absence of decomposed rocks from these regions to a process of denudation during successive ages, which culminated at the time of the submergence of the northeastern Appalachians at the end of the Pliocene period, when the remaining softened material was swept away by the action of water and ice, and the hard, unchanged rocks beneath were exposed and glaciated; since which time the chemical decomposition of the surface has been insignificant.

As we proceed southwestward from New York we find that the partially decomposed and disintegrating portion of these rocks which, in the Blue Ridge, lies beneath the clays, has escaped denudation, and we at length reach the region in Southern Virginia and Carolina, where these clays, the result of complete decomposition, are seen in nearly vertical strata forming the superficial soil. These ancient clays, formed by the sub-aerial decay of the crystalline feldspathic and hornblendic rocks of the great Eozoic continental areas, were, according to the speaker, the source of the argillaceous strata of the Cenozoic, Mesozoic and Paleozoic periods, and in the heights of the southern Appalachians we have still remaining a portion of that Eozoic land, which has stood throughout all these ages, undenuded, unglaciated, unsubmerged, and from its peculiar nature (being composed, as already described, of highly inclined, porous and permeable strata, supporting an abundant vegetation), but little subject to the degrading influences of atmospheric waters.—*Boston Soc. Nat. Hist.*, Oct., 1873.

2. *Geological Survey of Missouri:* Raphael Pumpelly, Director. *Preliminary Report on the Iron Ores and Coal Fields, from the field work of* 1872. 442 pp. large 8vo, with 190 illustrations in the text, and an Atlas. Printed by the authority of the Legislature of Missouri. New York, 1873 (Julius Bien).—The Geological Survey under Prof. G. C. Swallow, begun in 1853, was suspended in 1861, in consequence of the war, without the publication of a general report of the results which had been obtained. One important volume of nearly 450 pages had been published in 1855; and besides this, only brief annual reports for 1857, 1859 and 1861. The new survey, of which the Report just now issued is the first published result, was inaugurated in 1871, when a "Mining, Metallurgical and Geological Bureau" for the State of Missouri was organized. In 1872, the Survey was commenced under Prof. Pumpelly, with the following assistants: G. C. Broadhead, R. Chauvenet, Prof. W. B. Potter, J. R. Gage, Dr. A. Schmidt, W. E. Guy, C. J. Norwood and A. Leonhard.

This first volume of the Reports contains, in Part I, a very full and valuable account of the Pilot Knob and other iron regions of the State, and their products. It commences with a chapter on the Geology of Pilot Knob and its vicinity by Prof. Pumpelly. This is followed by analyses of fuels by R. Chauvenet, and of iron ores and pig irons by A. A. Blair. Next follows a thorough discussion of the distribution, modes of occurrence, and characters of the iron ore-beds or deposits, by Dr. Schmidt.

Prof. Pumpelly states in his report that the Archæan rocks of

Pilot Knob are stratified "on an immense scale," and have the average strike N. 50° W. (true course), with the dip to the southwest. The rocks include granites and felsitic porphyries and porphyry-conglomerates. The Archæan ridges of southeastern Missouri are an extension of the Ozark range, rising like islands through the Lower Silurian strata. Pilot Knob is 1,112 feet high above St. Louis, 662 feet above its base, and 1,521 above tide. It consists at top of a stratum of porphyry-conglomerate 140 feet thick, the pebbles cemented by iron ore. The ore-bed below is 46 feet thick, and is divided by a layer of slate 10 inches to 3 feet thick; the ore-bed rests on clay-slate, below which there is a red jaspery porphyry, and other porphyritic rocks. The ore is hematite. Many details of great interest are contained in the several reports on the iron-region, of which Dr. Schmidt's occupies 150 pages.

Part II, or the following part of the volume, is devoted to geological reports on the Coal-measures of the State, and on the geology of several of the northwestern counties, by G. C. Broadhead; a report on Lincoln County, by Prof. Pollen; a report on the strength of building materials, by C. A. Smith; and a list of fossils from the Coal-measures, by C. J. Norwood.

According to Mr. Broadhead, the Coal-measures of the State cover an area of about 22,995 square miles, including 160 square miles in St. Louis County, 8 in St. Charles, and a few outliers in Lincoln and Warren, and the remainder in northwestern and western Missouri. The above area includes 8,406 square miles of Upper or Barren Coal-measures, about 2,000 of exposed Middle, and 12,420 of exposed Lower Coal-measures. The area over which there are coal beds 18 inches thick, within 200 feet of the surface, is about 7,000 square miles in extent. The maximum thickness of the Coal-measures is 1,887 feet. Mr. Broadhead has illustrated his excellent reports by numerous sections; they also contain many analyses of the coals, by Mr. Chauvenet.

The Atlas of the Report, in large folio, includes a topographical map of the Pilot Knob region; another showing its geology; another illustrating the magnetic character of the region; a map showing the distribution of the iron ores of the State; a geological map of Lincoln County; another of northern Missouri; besides various plates of geological sections. All are well engraved, and very neatly and tastefully colored. The volume throughout is an excellent commencement of the series of reports which may be expected from the survey now in progress.

Prof. Pumpelly having resigned the charge of the Survey, Mr. G. C. Broadhead has been appointed State Geologist.

3. *Return of Professor Marsh's Expedition.*—Prof. Marsh and party returned to New Haven, November 7th, after an absence of five months in the Rocky Mountain region and on the Pacific Coast. The present expedition had the same object in view as those of previous years, viz: a study of the vertebrate fossils of the west, especially those of the Cretaceous and Tertiary formations. The first explorations this year were made in the Pliocene deposits near the Niobrara River. The party fitted out in June at Fort

McPherson, Nebraska, and, accompanied by an escort of two companies of U. S. cavalry, proceeded to the Niobrara, and worked in that country for several weeks. Owing to hostile Indians, the explorations of the party here were attended with much difficulty and danger, but were on the whole quite successful. Many new animals were discovered, and ample material secured for a full investigation of those previously known from that region.

A second expedition was made in August from Fort Bridger, Wyoming, and large collections of Eocene fossil vertebrates were obtained, especially of the *Dinocerata* and *Quadrumana*, which had first been brought to light by the researches of the party in previous years. A third trip was made in September to the Tertiary beds of Idaho and Oregon, where some interesting discoveries were made. The party went from Oregon to San Francisco by sea, narrowly escaping shipwreck, and then returned east by rail. On the way, short visits were made to localities in the Miocene of Colorado, and Cretaceous of Kansas, to complete investigations began last year. The expedition as a whole was very successful, not merely on account of the large number of new animals discovered, but also on account of the extensive collections made to complete the study of those previously found. All of the collections secured are now in the Museum of Yale College.

4. *Contributions to American Botany;* by SERENO WATSON. I, II and III, 1873.—Although these important papers have been somewhat freely distributed among botanists, yet it may be useful here to note their contents, and to state where copies may be obtained. These and almost all similar publications, separate issues of articles contributed to scientific journals and proceedings of societies, may be had from the Naturalists' Agency, Salem, Mass. The great convenience of such a medium, and its importance in saving time, trouble and expense, are beginning to be appreciated.

Mr. Watson's Contribution No. 1 consists of recent gleanings from a field from which he gathered the first harvest in his botanical exploration along the 40th parallel under Clarence King. The great demand for the fine quarto volume, in which the results of his own botanical explorations through Nevada and Utah are contained, gives some idea of the value of the work. Two recent collections, made in a more southern district, viz: one by F. Bischoff in Lieut. Wheeler's exploration in 1871–72, and one by Mrs. Ellen P. Thompson, who accompanied her brother, Major Powell, in his survey of the Colorado, having been consigned to Mr. Watson for study, the new species they contained are here published in brief diagnoses, in the American Naturalist for May last. They are between twenty and thirty in number. The three most interesting plants are new species of peculiar genera, hitherto only monotypic: *Peteria Thompsoniæ*, *Whipplea Utahensis*, and *Petalonyx nitidus!* The separate issue is a pamphlet of five or six pages, and, we are sorry to say, is separately paged. The editors of the Naturalist, we trust, will hereafter keep the original paging in all such cases, for the paramount sake of facility and uniformity in citation.

Contribution No. 2, although communicated to the American Academy of Arts and Sciences as early as May 13, is published only in November. It fills the pages of the Proceedings of that Academy, vol. viii, from p. 517 to p. 618. It comprises: 1. *A revision of the extra-tropical species of the genus Lupinus*—a difficult monograph, in which 56 species are described under a systematic arrangement, and the synonymy and bibliography appended with great pains and particularity in eight or nine pages of fine type. As it would be simply impossible to clear up this genus without reference to the original types of the species published by Agardh and Lindley, it should be stated that the revision, in this regard, is based upon a collocation by Dr. Gray, at Kew, of his own specimens with those of Lindley's (the basis of Agardh's synopsis), and of Hooker's herbarium. Although this is not the same as having all these materials in the hands of the final monographer, yet there is good reason to expect that the earlier species are generally well identified. Several new ones are added, and the whole is put in such order that we may hope the genus will no longer be the most difficult one of its size in North American phænogamous botany. 2. *A revision of the extra-tropical species of Potentilla*, excluding *Sibbaldia*, *Horkelia* and *Ivesia*. 3. *Œnothera*, in a similar revision. These genera, which have much needed re-elaboration, are here worked upon the same plan as that for *Lupinus*. First, there is, in small type, a synopsis of the sections and species, serving as a key; then the fuller descriptions, with little or no synonymy; then, in small type, full synonymy and references, under an alphabetical order of the admitted species, including also collector's numbers; and, finally, a table of cross-references of synonyms to the species. It is pleasant to see such neat and faithful work.

Contribution No. 3, on *Polygonum*, section *Avicularia*, after some prefatory remarks, disposes of fourteen North American species of this troublesome group, we hope satisfactorily; only one of them, *P. Torreyi*, from California, absolutely new; and a new section *Duravia*, is made for Meisner's *P. Californicum*, which is separated from the *Avicularia* section "by every character but habit." This short paper was published by the American Naturalist, in the November number.

5. *Characters of New Ferns from Mexico;* by Daniel C. Eaton.—Being two new *Polypodia* and an *Asplenium*, from a collection made at Chiapas, a southern province of Mexico, by Ghiesbreght, which Prof. Eaton has recently distributed, extracted from Proceedings of the American Academy, for May 13, 1873.

The eighth volume of these Proceedings, under the same date, contains a paper (also issued in a separate edition), entitled

6. *Botanical Contributions*, by Asa Gray, bearing date of issue November 18, 1873. This contains, 1. *Characters of New Genera and Species of Plants.* The new genera are *Brewerina*, a new Caryophyllaceous genus (said to be "*Silenearum*," but this is a misprint for *Alsinearum*, as the context shows), from the Sierra

Nevada in California, therefore appropriately dedicated to Prof. Wm. H. Brewer of Yale College, from whom we are expecting the Flora of California; and *Ghiesbreghtia*, a striking new Scrophulariaceous genus from Southern Mexico. As to new species, all but one are from the Rocky Mountains, or farther west. The eastern one, of particular interest, is *Pachystigma Canbyi*, a second species of this formerly monotypic genus, discovered by Mr. Canby in the Virginian Alleghanies. Here is a western genus now augmented by an eastern species, evidently very local, and overlooked until Mr. Canby set eyes upon it. "To redress the balance," a new Californian *Dirca* is here published, *D. occidentalis*, which represents our *D. palustris* on the western verge of the continent. 2. *Notes on Compositæ and Characters of certain Genera and Species*, is in some sort a review of a portion of the new part of Bentham and Hooker's *Genera Plantarum*, so far as it came in the way of a particular line of study, with some revisions, new species, &c. The most extensive is the monograph of the re-established and augmented genus *Bigelovia*. The "golden crown" to which DeCandolle gracefully alluded when he founded the genus, almost thirty years ago, in honor of Dr. Jacob Bigelow, now in his old age, has its stars increased to the round number of twenty-four. A. G.

5. *Yucca gloriosa*.—Since our notice of Dr. Engelmann's Monograph of *Yucca* was printed (in December number), we learn from him that *Y. gloriosa* has fruited in the Congressional Garden at Washington, where it has been examined and photographed by Dr. Schott. This species proves to have a dry capsular pod, like that of *Y. filamentosa*, not a baccate fruit, as Elliott, Nuttall and, after them, Chapman supposed. What they took for the fruit of this species must have belonged to *Y. aloifolia*. A. G.

6. *Arundo Donax in Virginia*.—Along the banks of a stream, about five miles southeast of the Peaks of Otter, in the Blue Ridge, Virginia, Mr. A. H. Curtiss, this autumn, found in flower a tall reed, from fifteen to eighteen feet high, which proves to be *Arundo Donax*, or at least is not to be distinguished from it as to the inflorescence and spikelets; the leaves not seen by me. There are one or two almost peculiarly European plants in the Virginian Alleghanies, such as *Convallaria majalis* and a large form of *Anemone nemorosa*, seemingly passing into *A. trifolia*, which Mr. Curtiss discovered last year. But *Arundo Donax* belongs to the Mediterranean region, and is not a plant which would be expected to endure, still less to be indigenous in our Alleghanian region. I have no idea that the imported plant would survive there. The fact of its survival, and the circumstances under which it occurs, render it probable that it is no new comer. A. G.

7. *Trichomanes radicans in Kentucky*.—This discovery, which unexpectedly adds this fern to the botany of the northern United States and extends its range up to about lat. 38°, will be mentioned more particularly in a later number of the Journal. A. G.

8. *Flora Australiensis;* by George Bentham, assisted by Baron Ferdinand von Müller. Vol. VI. *Thymeleæ to Dioscorideæ.* 8vo, pp. 475. 1873.—The fifth volume appeared in 1870. Since then Mr. Bentham has been able to bring out this new volume, besides re-elaborating the whole order *Compositæ* for the *Genera Plantarum*, not to speak of other things. That the work is not slighted may be inferred from a remark incidentally made under the *Orchideæ*—the largest order in this volume, and particularly tedious and difficult to study in dried specimens —that, "In this case, as in the rest of the present work, I have made it a rule to work out the descriptions of genera as well as species, in the first instance from the specimens themselves, wherever they admitted of examination, and afterward to check them by those of the great authorities on the order."

The more noteworthy points which have attracted attention in turning over the pages are the following: *Phaleria* of Jack is an older name for *Drymispermum* of Reinwardt. A *Nepenthes* has been discovered in Australia; yet it may be a form of *N. phyllamphora. Trema* of Loureiro replaces *Sponia*, the character of the former being not only earlier but as definite as Commerson's of the latter. The carpological characters of *Coniferæ* are given with an *alias*, although the gymnospermous view is adopted, "as most conformable to the actual appearance," "without, however, intending to decide the question, which is still the subject of keen controversy." The *Hæmodoreæ* are reduced to a tribe of *Amaryllideæ.* A. G.

9. *Flora Brasiliensis*, fasc. 62, issued in June last, of 180 pages and 50 plates, commences the *Compositæ*, and contains the tribe *Vernoniaceæ;* by Mr. Baker of Kew. This tribe is largely represented through the eastern side of South America, increasing in number southward. Although diminished by the separation of several small groups, 178 species of *Vernonia* are here described as belonging to Brazil. A. G.

10. *Musée Botanique de Leide*, par W. F. R. Suringar. Vol. I. livr. 1–3. 4to. The second titles are *Illustration des Espèces et Formes du Genres d'Algues; Gioiopeltes.* 1871–2: with twenty-two plates. *Illustration des Algues du Japon*, with four plates. —With this elegant work, the letter-press and illustrations in the best style, Prof. Suringar begins anew the botanical publications of the researches made in the Royal Herbarium at Leyden, which had been interrupted by the death of Professor Miquel. The *Algæ* of Japan will be of special interest in this country. Some good work done by the late Professor Harvey, upon collections sent from this country, still remains unpublished. A. G.

11. *De Candolle's Prodromus, pars decima septima*, issued Oct. 16, 1873, has come to hand. The contents are, in the first place, certain small outlying orders, or some of them genera, that have to do duty as orders, which on various accounts have been left out of the Prodromus as it went on, viz: *Sarraceniaceæ, Phytocreneæ, Cardiopterideæ, Salvadoraceæ, Cynocrambe, Bati-*

daceæ (one *Batis*), *Lennoaceæ* (by Solms-Laubach), *Podostemaceæ* (by Weddell). Then *Nepenthaceæ*, by Dr. Hooker; *Cytinaceæ*, by the same; *Balanophoraceæ*, by Eichler; *Ulmaceæ*, by Planchon; *Moraceæ*, by Bureau; and a synopsis of the genera of *Artocarpeæ*. For the complete elaboration of this last family the volume has been a good while kept back, and has at length been issued, and (sad to say) the work concluded, without it. It is to be hoped that whenever M. Bureau finishes his undertaking, the publishers of the Prodromus may print the *Artocarpeæ* uniformly with the rest, so that it may be appended.

Then follow a few pages of *Genera omissa*, with brief references, indicating what they are, or may be, so far as has been made out or conjectured; and finally, the wearied editor appends his *Prodromi Historia, Numeri, Conclusio.* It is a terse and highly interesting account of this work, which (including the two preceding volumes of *Systema*) occupied his celebrated and indefatigable father from the year 1816, or earlier, down to the end of his life, in 1841, and himself to the close of the past year; an enumeration of the contributors, who have worked up particular families or genera; an enumeration of the orders, specifying the volume which contains each, and the number of genera and species described, 5134 genera and 58,975 species, which the missing *Artocarpeæ*, it is estimated, would bring up to 5163 genera and about 60,000 species of *Dicotyledones.* Among a few statistical data which are given, the ten orders are enumerated which contain the greatest number of genera, beginning with *Compositæ* and ending with *Cruciferæ.* Then the ten which most abound in species, which begin with *Compositæ* (8561 species) and end with *Umbelliferæ* (1016). *Leguminoseæ* are the second in both lists, and next *Rubiaceæ* in the former and *Euphorbiaceæ* in the latter. But the long interval between the publication of many orders, say between *Cruciferæ* and *Euphorbiaceæ*, much diminishes the value of such comparisons. The reasons which have prevented a more rapid publication of the volumes of the Prodromus, especially since the work has been largely distributed among collaborators, are hinted at; and finally the regretable announcement is made that the publication is now relinquished, at the close of the *Dicotyledones.* A full Index, down to genera and their sections, filling 170 pages, closes this great work.

We sincerely congratulate the editor upon the successful completion of this great undertaking at the limits he felt obliged to prescribe, and thank him heartily for his long and faithful service and many sacrifices. As it may be hoped that he has still years of good work in him, all will regret that he could not bear this burden through a few of them, while a half dozen collaborators, who might be named, elaborate the Monocotyledonous orders. But, as he declares that he should doubtless perish under it, we prefer the living botanist to the completed *Prodromus.* We may expect from him original work instead of editorial drudgery, perhaps a new edition of his Geographical Botany, or new researches upon the same subject, investigated with his impartial judgment, under the new light which was just dawning when that comprehensive treatise was published.

Since these remarks were written we have received an interesting pamphlet, separately issued from the *Archives des Sciences* of the *Bibliothèque Universelle* for November, entitled, *Reflexions sur les Ouvrages Généraux de Botanique Descriptive.* In this M. de Candolle gives the history of the Prodromus and its forerunner with considerable fulness, explains more particularly his editorial trials and burdens, and the reasons why the work could not be made to get on faster, and gives his views as to the most practicable method of combining the labors of the botanists of another generation in the production of the new *Systema Vegetabilium* which will be demanded. An estimate is made of the time it must needs require, even with all the available monographers of the day enlisted in the service. The increased difficulties, or at least the augmented labor, of systematic botanical work, under the present demands of the science, are indicated. It appears that, while in his father's time one could elaborate at the rate of about ten species a day, a faithful monographer now, under the modern requirements, can seldom exceed three or four hundred species *per annum*, that is, about a species a day! We suppose that the case on the whole is not overstated. A. G.

12. *Description of a new Genus and Species of Alcyonoid Polyp;* by ROBERT E. C. STEARNS. (From the Proceedings of the Cal. Academy of Sciences, August 18, 1873.)—At a meeting of the California Academy of Sciences, held on the third day of February, 1873, a paper was read by me, entitled "Remarks on a New Alcyonoid Polyp, from Burrard's Inlet;" * in which I gave a *resumé* of the discussions, notices, etc., in this country and in England, arising from the examination by several naturalists of certain "switch"-like forms, which had been received by different parties from the Gulf of Georgia (more particularly from Burrard's Inlet, in said gulf), several specimens of said "switches" being in the Museum of the California Academy.

These "switches," or rods, were referred by Dr. Gray, of the British Museum, to his genus "Osteocella," and by Mr. Sclater's correspondent stated to belong to "a sort of fish;" but by the majority of scientific gentlemen who had seen these "switches" they were regarded as belonging to a species of Alcyonoid Polyp. I expressed the belief that they belonged to a species of *Umbellularia.*

At a meeting of the California Academy, held on the evening of August 4, 1873, Dr. James Blake presented a specimen of the polyp of which these so-called switches are the axes, which had been sent to him from the Gulf of Georgia by his friend, Capt. Doane. This specimen was one of six or seven sent at the same time, all of which were in a tolerable state of preservation, though, as might have been anticipated, the more delicate tissues of the

* *Vide* Proceed. Cal. Acad. Sciences, vol. v, part I, pp. 7—12.

polyps are somewhat decomposed, and some of the specimens are in some places lacerated. They all are, however, sufficiently perfect to determine the true position, and show that the "switches" are, as was supposed, the supporting stalks or axes of an Alcyonoid Polyp "related or pertaining to the group *Pennatulidæ*."

At the last meeting, I referred the specimen before the Academy to that division of the *Pennatulidæ* known as *Virgularia;* but, upon a subsequent examination of the authorities, I find that those forms in which the axis is unilateral, or on one side, come within the genus *Pavonaria* of Cuvier.

The only species heretofore described, so far as I can learn, and on which this genus is based, is *P. quadrangularis*, of which a long and interesting description from Prof. Forbes is given in Johnston's British Zoöphytes (vol. i, pp. 164–166). In that species, however, the axis is "acutely quadrangular," and the polyps are arranged in three longitudinal series, corresponding to three of the "angles of the stem."

In the specimen presented by Dr. Blake, the style of axis is round and the polyps are arranged in two longitudinal unilateral series, which conform to the convexity of the external fleshy covering. With these differences, I think I am justified in placing it in a new sub-genus, for which I propose the name of *Verrillia*, in honor of Prof. Verrill of Yale College.

Genus Pavonaria Cuvier. Sub-genus *Verrillia* Stearns.—Polypidom linear-elongate, round, oval or ovate in cross-section. Axis round, slender, bony; polyps arranged in two unilateral longitudinal series.

Verrillia Blakei Stearns, n. s.

Polyp-mass or polypidom of a flesh or pink color, linear, elongate, attenuate; polypiferous portion about three-fourths of the entire length, rounded oval to ovate-elliptic in cross section, and from three-fourths to one inch in greatest diameter, flatly tapering toward the tip, as well as decreasing in the opposite direction to where the polypiferous rows terminate or become obsolete. From this latter point to the beginning of the base or root, a portion of the polypidom, equal to about one-sixth of its entire length, is quite slender, being only about twice the diameter of the naked axis, and the surface quite smooth; said portion, as well as the base, is round (in cross section); the basal part is from one-ninth to one-eleventh of the entire length, and about one inch in diameter, with the surface longitudinally wrinkled or contracted, presenting a ridged or fibrous appearance.

Style or axis long, slender, white, hard, bony, somewhat polished, about three-sixteenths of an inch in diameter in the thickest part, tapering gradually toward the tip, and attenuated, with surface somewhat roughened toward the basal extremity. Inclosed in the polyp-mass or polypidom, the axis is central from the base to where the polyp-rows begin, when it soon becomes marginal or lateral, forming a prominent rounded edge (free from polyps) on one side of the polypiferous portion of the whole.

From near the sides of the axial edge, the polyp-rows start, and run obliquely upward to the opposite side, where they nearly meet, presenting, when that side is observed from above, a concentric chevron or Λ-like arrangement, modified by the convexity of the polypidom. The more conspicuous polyp-rows show from nine to fourteen polyps, with occasional intermediate rows of three or more polyps.

The length of the most perfect of Dr. Blake's specimens was *sixty-six* inches; of which, commencing at the tip, a length of forty-eight and a quarter inches was occupied by the polyp-rows, which numbered two hundred and forty-five, or twice that number when both sides or arms of the chevron or Λ are considered. The number of polyps in each row was, in this specimen, from eight to eleven, with occasional intermediate shorter rows of from three to seven. Estimating ten to the row, this specimen exhibited about *five thousand* polyps, all of which, as well as the polyps in the other specimens, were filled with ova, of an orange color. In the next section of this specimen, the length between the last polyp-row and the swell of the base or root, is eleven and one quarter inches; thence to the termination of the base, six inches.

The average dimensions of thirty-six of the axes in the Museum of the California Academy is five feet six and one-third inches in length, and the diameter of the largest, nine thirty-seconds of an inch; diameter of smallest specimen, one-sixteenth of an inch.

Dr. Blake's specimens were preserved in a mixture of glycerine and alcohol; and the more delicate tissue of the polyps appears to have been somewhat injured by the latter ingredient.

Additional specimens of the above species, from the same locality, have been received from J. S. Lawson, Esq., of the U. S. Coast Survey, by George Davidson, Esq., President of the Academy. These latter were put in glycerine only, and are in better condition than those received by Dr. Blake.

Of the specimens received from Mr. Lawson, some individuals are younger than either of Dr. Blake's. In these the polyp-rows are farther apart, and there are not so many polyps in the row; neither do the ends of the rows approximate so closely on the side opposite the axial edge, the polyps being not nearly so many in the same length, or presenting (as do some of Dr. Blake's specimens) so crowded an appearance. In cross-section through the polypiferous portions, the younger individuals are less oval or acutely-ovate than the older specimens. A comparison of individuals indicates an external differentiation, analogous to that displayed by specimens of the same species in *Virgularia*. The general aspect of this species, judging from the figure in plate XXXI of Johnston's British Zoophytes (2d ed.), is like *P. quadrangularis* from Oban, only, in that species, the rows of polyps, it is stated, are composed of "four, five or six polyps in a row," one figure showing seven.

Note.—A recent examination of a specimen, convinces me that this species is most nearly allied to the *Halipteris Christii* Kölliker (Koren and Dan., sp.) and probably ought to be referred to the same genus.—A. E. VERRILL.

III. Astronomy.

1. "*Rapporti sulle Osservazioni dell' Eclisse totale di Sole, del 22 Dicembre*, 1870, eseguite in Sicilia dalla Commissione Italiana."—This work is a quarto of 214 pages, handsomely printed and gotten up, and illustrated with fourteen fine lithographic plates. It is published at the expense of the Italian Government, under the editorship of Professor G. Cacciatore, the Vice-President of the Commission, and is in all respects a most creditable exponent of the scientific activity of Italy.

The Commission was named by a Royal decree, dated July 5, 1869, and originally consisted of Professors Santini, Cacciatore, A. de Gasparis, Donati and Schiaparelli. At their first meeting, they added to their numbers Father Secchi and Professor Blaserna, and at the same time elected the venerable Santini as their President, and Cacciatore as Vice-President.

The volume opens with a short letter addressed to the Minister of Public Instruction by Santini, recounting the organization of the Commission, explaining the writer's part in the work, (which, on account of his advanced age, was chiefly that of general supervision,) and returning thanks for the zeal and energy with which the minister entered into and seconded their plans.

This is followed by a more extended and very interesting paper (*relazione*) by Prof. Cacciatore, upon whom fell most of the labor of organization and arrangement of details. This labor was much increased by the disturbed condition of Europe, which rendered it very difficult to procure some of the needed instruments, and finally, on this account, compelled material changes in the programme of operations.

At the stations occupied by the Italian Commission, the weather also during the eclipse was of the same character as at all the others, cloudy with mere snatches of clear sky, so that altogether he found his labors arduous and rugged ("*ben ardua e scabrosa*"), and the results but partially satisfactory. We copy his summary in his own words:

"As soon as nature resumed its course, I was able to satisfy myself that if the sky had not been largely propitious, it had yet conceded to us a certain interval, the fruits of which had been reaped to the uttermost, and that, if on the whole the observations of the eclipse of 1870 had failed of success (*riuscirono disgraziate*), yet the Augusta division would be able to present some facts not unimportant in the present state of science." * * * * "Father Secchi had undertaken the photography and the spectroscopic examination of the protuberances before the eclipse, with the view of comparing their appearance thus observed with that presented during the eclipse. Their form and position were obtained during the morning under a favorable sky. The first contact was observed by him with a chronometer.

"Ten photographs were obtained during the phases, and at the moment of totality a photograph of the protuberances, in spite of interposing clouds. The spectrum of the acute cusps of the sun was also studied.

"Prof. Denza made spectroscopic observations of the corona, which revealed two bright lines, one near E, the other probably of nitrogen. [*Very doubtful.*—Y.] Together with Sig. de Lisa he observed and sketched the prominences. Prof. Donati, during the totality was able to catch the lines in the spectrum of one protuberance which he had observed before the eclipse. He saw the hydrogen lines and D_3, but none of the iron lines.

"Prof. Blaserna examined whether the corona contained polarized light. Using a Savart polariscope applied to a telescope of moderate magnifying power, he was able to examine carefully three points situated about 45° from each other (*on the sun's limb*). The polarization was most pronounced, and very nearly the same as that of a portion of clear sky observed soon after, about 50° from the sun. At the distance of a diameter and a half from the moon every trace of polarization vanished, so that the influence of the air was certainly eliminated in the observed phenomenon.

"The plane of polarization was found at all points either radial or tangential to the sun's limb [*the observations not deciding with certainty which*]. It remains therefore established that the corona is polarized, and contains reflected light derived from the photosphere.

"The purely astronomical part assigned to myself was executed to the best of my ability, so far as the variable condition of the sky permitted. I was able in fact to note with some precision the instants of first contact, of the beginning of totality, and of its ending (the last through clouds), besides making some other observations to be referred to hereafter.

"The magnetic and meteorological observations which since the 10th had been kept up hourly, were taken at intervals of five minutes, beginning at noon of the 22d. Sig. Bonifacio, who was especially charged with this work, was aided in it by Prof. Cultrera of Palermo, who having come to Augusta to witness the phenomenon, begged earnestly to participate in the labors of the Commission.

"The division at Terranova found themselves in circumstances very similar to those which prevailed at Augusta; here also the observers were annoyed by tempestuous winds and opposed by clouds; but notwithstanding, some good and not unimportant observations were obtained. Prof. Lorenzoni detected in the spectrum of a protuberance, besides the hydrogen lines and D_3 a large number of bright lines ('*more than twenty*'). In conjunction with Prof. Tacchini, he made excellent sketches of the protuberances as seen with the telescope, and carefully determined the position of one green line in the spectrum of the corona.

"Prof. Nobile was able to observe the spectrum of the cusps (*showing 'at least forty bright lines'*).

"Prof. Legnazzi, rising from a sick bed to fulfill his part, observed the contacts and the protuberances. The physical features of the eclipse were studied by Sigs. A. Tacchini, Solito and Rizzo, the phenomena of the shadow by Capt. Serra.

"Finally, Sig. Muller considered that his magnetic observations brought out an important fact, never before observed, viz: that of a magnetic disturbance, simultaneous with the phases of the eclipse, perceptible at all the stations, but diminishing in amplitude as the distance from the center of the shadow increased."

Following this "*relazione*" of Prof. Cacciatore, and forming the principal portion of the book, come the detailed reports of the different observers, describing their stations, apparatus and modes of observation, the operations for the determination of time and geographical position, and the results arrived at by each. Part First contains the reports of the observers of the Augusta division, in the following order: Secchi, Donati, Cacciatore, Blaserna, De Lisa and Denza. Part Second contains the Terranova reports from Lorenzoni, Legnazzi, Nobile, A. Tacchini, P. Tacchini, Muller and Serra.

An appendix of some 17 pages contains certain observations of Prof. Serpieri, Cav. Buffa di Ferrero and others, for the most part designed to determine very exactly the northern limit of the shadow on the Italian coast.

Our space will not permit any extended analysis of these numerous papers, among which those by Secchi, Blaserna, Denza, P. Tacchini, Lorenzoni and Nobile appear to be the most interesting and important. Such an analysis, however, is less needed, since for the most part the results obtained agree with those of the American and English observers, which are well known to our readers.

Prof. Denza, however, thus far stands alone in his observation of the second bright line in the spectrum of the corona; and the observation of Sig. Muller, as to a magnetic disturbance accompanying the progress of the shadow, failed of confirmation in the Indian eclipse of 1871.

It is to be noted, moreover, that both Denza and Lorenzoni agree in declaring the position of the green corona line to be at 1463 of Kirchoff's scale, and not 1474, as given by Young. In this they are certainly mistaken. We think that any one who will read the account of the manner in which the determination of the American observer was made [this Journal, Nov., 1869, and May, 1871; also Nature, vol. iii, p. 272, and vol. vii, p. 28,] will be quite satisfied as to this point.

Prof. Denza's determination was confessedly a mere estimate; that of Lorenzoni was a careful scale-reading, three times repeated, with a direct vision spectroscope having about twice the dispersion of the ordinary single-prism chemical instruments—if, at least, we may judge from the separation of the D lines indicated by the scale-reading.

He writes, "As soon as the totality was ended, I re-compared the solar spectrum, and found that the position of the corona-line coincided exactly with that of line No. 21 of the spectrum of Vander Willingen—1463 Kirchoff.

"The same consequence also results from the following readings made upon the scale, viz: D^1, 73·2; D^2, 73·6; corona line, 118·5; b^1, 133·5; b^2, 134·8; b^3 135·2."

The force of this last sentence is not very evident, since, if we take Kirchoff's numbers for the D's and b's [1002·8, 1006·8, 1634·1, 1648·8 and 1651·7], we find, on performing the interpolation, that 118·5 of Lorenzoni's scale comes out correspondent with 1478·3 Kirchoff, instead of 1463. Since the probable error of a reading is stated by Prof. Lorenzoni, in a note dated March, 1872, to be four divisions of Kirchoff's scale, the agreement with Young's result would seem to be as close as could be desired. We should not have noticed this point so particularly were it not evident, from the note referred to, that the Italian observers, after having their attention specially called to the subject, were still disposed to prefer their own result to that which is generally accepted.

C. A. Y.

IV. Miscellaneous Scientific Intelligence.

1. *Note on Subterranean Fishes in California;* by A. W. Chase. (Communicated to one of the Editors.)—In collecting facts about the *Artesian wells of the lower Counties*, I received the following curious information from Mr. Bard, the agent of the California Petroleum Company at San Buenaventura. He has lately constructed a wharf at Point Hueneme, southeast of San Buenaventura. Wanting water to supply this wharf, he commenced sinking an artesian well on the *sea beach*, not five feet from high-water mark. At the depth of 143 feet, a strong flow of water was obtained, which spouted forth to a height of thirty feet. It was controlled with a "goose neck" and utilized. One day while the agent was absent, the men around the well noticed fish in the waste water. On his return they called his attention to the fact, and on examination the well was found to be filled with young trout, thousands of them being thrown out at every jet. These trout were all the same size (about two inches long), and perfectly developed. The first examination made was to see whether they had *eyes*. These were found perfect. Now there is no stream nearer than the Santa Clara River, several miles distant. Could these fish then have come from its head-waters by some subterranean outlet? There are no trout in the lower portions of the stream. The temperature of the water is the same as that of the wells in this county, viz: 64° Fahr., too warm of course for trout to live long in it.

2. *La Naturaleza, Periodico cientifico de la Sociedad Mexicana de Historia Natural*, in monthly numbers of 24 to 32 pp., large 8vo. Mexico.—This publication of the Mexican Society of Natural History was commenced in June, 1869, and is now in charge of Señor Mariano Barcena, 1st Secretary of the Society. It contains the papers read before the Society, treating of all departments of science. Among these are papers on Mexican Insects and Vertebrates, by D. E. Dugés (one on a new species of Axolotl); on Insects, by D. J. Blasquez; on Mexican Helminthology, by D. A.

Peñafiel; the geographical distribution of birds, by D. F. Sumichrast; on Mexican Mammifers, by D. M. M. Villada; on Cacteæ, by D. J. M. Velasco; new grasses, by D. V. Cervantes; habits of *Quiscalus macrourus*, by D. M. Barcena, and among the others the following:

On a new Mexican mineral, by Don Pedro L Monroy (i, p. 76). The mineral contains chiefly bismuth and tellurium, with perhaps a little sulphur, arsenic and silver. G.=8·23; H.=3·75–4, on the scale of Breithaupt; luster metallic; color between steel gray and the white of antimony, but tarnishes to bronze and iron black; powder grayish-black; somewhat ductile. The specimen was labeled from the mine of Coneto, near Durango.

On some combustible minerals of Mexico, by Don P. L. Monroy (i, p. 87). The paper contains analyses of coals and lignite, from La Villa de Panuco, Vera Cruz; between Xilitla and Jacala; Xilitla; Pez de Jalapa; Yahualica, State of Hidalgo; Chilpangingo, State of Guerrero; Paso del Norte, Chihuahua; Zacualtipan, Hidalgo; Texmelucan, Puebla.

Ascent of Popocatepetl in 1865, by A. Dolfus, E. de Montserrat and P. Pavie, with two plates of views and sections. The heights measured are: the summit of Popocatepetl, 5,425 meters; bottom of the crater, 5,119 meters; diameter of the crater at top, 825·68 meters; height of Ixtaccihuatl, 5,207 meters. Eruptions have taken place from Popocatepetl in the years 1519, 1530, 1548, 1571, 1592, 1642, 1664, 1802.

On the active volcano, Ceboruco (near the village of Ahuacatlan), by Don A. Caravantes, with a plate. The height of the volcano above the sea-level is 1,525 meters.

On the meteoric irons of Mexico, by D. J. Correjo (i, p. 252). A review of the facts, including analyses, which have been published with regard to Mexican meteorites, and some additional facts. A recent number contains an indignant protest of the society with reference to the destruction of the large meteorite, called the "Descubridora," ordered by the Mexican Society of Geography and Statistics.

3. *Notes on a Metallurgical Journey in Europe;* by JOHN A. CHURCH, M.E., with 22 illustrations. New York, 1873. 8vo, pp. 102. (Van Nostrand).—So much exact and valuable information on a technical art is rarely crowded into the same space as is to be found in the one hundred closely printed pages of Mr. Church's "Notes" of his metallurgical journey in Europe. The topics discussed are concisely handled in the analytic method, and with a fullness of detail which makes the work of permanent value. The copper process at Agordo; the mercury works at Valalta; the lead works at Mechernich; the gold and silver works at Lend; occupy 53 pages, rich in information and details drawn from the most authentic sources. Since 1870 the processes at Freiberg have been so much changed that Mr. Church's chapter of 28 pages devoted to them will be read with great interest. The lead and silver works of the Hartz Mountains, Clausthal, Lautenthal, and the copper process at Altenau, complete this use-

ful and unpretending memoir, which appeared first in a series of articles in the Engineering and Mining Journal of New York during the past year.

4. *Qualitative Chemical Analysis. A Guide in the Practical Study of Chemistry and in the work of Analysis;* by SILAS H. DOUGLASS, Professor of Chemistry, and ALBERT B. PRESCOTT, Professor of Applied Chemistry in the University of Michigan. Ann Arbor; 1874. 8vo, pp. 259.—Messrs. Douglass and Prescott have embodied in this volume the results of their own experience in the management of the classes in qualitative analysis in the University of Michigan. For those commencing the study of chemical analysis, this book will be found convenient as embodying in one volume what is most essential to be known, and presenting the subject with a fullness of detail in some particulars not always found in similar works The dark-faced barred type are retained in the formulas, which we think is to be regretted as tending to confuse the mind of the student, where there is no occasion for such confusion if the atomic notation was strictly adhered to. Following the systematic discussion of the metals, nonmetals and acids, are lists of solubilities of salts with reference to bases and acids; a table of relative solubilities; and two tables for the systematic qualitative analysis of simple and complex substances, both in the dry and wet way. These are substantially the same tables which Prof. Douglass published in successive editions in 1864–65 and 1868, for use in connection with Fresenius' Manual of Qualitative Analysis. A list of chemical reagents closes the volume, which the authors hope may aid "to prevent habits of mechanical manipulation and of superficial observation in analysis."

5. *The Service Monthly, a Monthly Journal devoted to Meteorology, Military Telegraphy and the Signal Service.* Vol. I, No. I, November. 32 pp. 8vo. ($2 per year). Washington, D. C. (1721 G street).—This first number of a new journal contains the following articles: The Florida Cyclone of October, by Lieut. T. Smith, U. S. A., with two maps; Synopsis of the Report of the Chief Signal Officer; The great Oceanic Cyclones, by Prof. T. B. Maury; The Prussian and the French Field Telegraph, translated by Lieut. T. Smith; Description of a Self-recorder for Anemoscope and Anemometer, by Lieut. D. J. Gibbon, U. S. A.; Monthly Weather Review for October, with a map; Means of Barometer, Thermometer, Humidity, Wind, etc., for the month of October.

6. *Museum of Comparative Zoölogy at Cambridge, Massachusetts.*—The Museum of Comparative Zoölogy has been placed under the direction of Mr. Alexander Agassiz, son of Professor Agassiz, and Mr. Carey, both of whom are thoroughly conversant with Professor Agassiz's plans with regard to the Museum, and familiar with the collections.

7. *Walker Prize of the Boston Society of Natural History.*—The first award of the Walker prize of $1,000 has lately been made, by the Boston Society of Natural History, to Mr. Alexander Agassiz, for his recent researches and memoirs on the Echinoderms.

Ueber Louis Agassiz

veröffentlicht der vielgenannte Carl Vogt einen Artikel, dem wir die folgenden Notizen entnehmen;

„Ich sah Agassiz zum ersten Mal in meinem väterlichen Hause in Bern, wenn ich nicht irre, während einer schweizerischen Naturforscherversammlung, gegen das Ende meiner Studienzeit—er war etwa dreißig Jahre alt, ich zehn Jahre jünger. Ein gewinnender Zauber lag über dem Manne; aus dem schönen Gesichte blitze der heiterste Jugendmuth und die Gesellschaft, die sich an dem großen runden Tische meiner Eltern versammelt hatte, war gerade nicht in der Stimmung, Mücken zu seigen und Kameele zu schlucken. Es wurde gelacht, gescherzt, dazwischen auch wohl etwas Ernsthaftes, wenn auch nicht immer Bedeutendes gesprochen, bis tief in die Nacht hinein; die Götter des wissenschaftlichen Olymps hüllten sich in keine anderen Wolken, als den Rauch der Pfeifen und Cigarren und hatten für die kurzen Stunden das Katheder vergessen, das Mancher von ihnen später pedantisch auf Schritt und Tritt mit sich herumschleppte. Des andern Tages kam Agassiz wieder, dieses Mal allein. Es war gewissermaßen mit unserem Hause ein engeres Verhältniß durch den Umstand angebahnt worden, daß mein Freund Desor, der längere Zeit bei uns zugebracht hatte, von ihm zu seinen Arbeiten zugezogen worden war und jetzt bei ihm in Neufchatel lebte. Die Medizin stand mir schon im Halse oben, wenn ich gleich fest entschlossen war, ihr Studium zu beenden. „Es ist ein Sattel," pflegte mein Vater zu sagen, „auf dem man durch die ganze Welt reiten kann; bist du einmal Doktor und patentirter Arzt und hast Recht über Leben und Tod, so kannst du nachher das Rößlein laufen lassen—aber damals galt es noch, mich in den Sattel zu schwingen, obgleich ich immer große Sehnsucht danach hatte, in Anatomie und Entwicklungsgeschichte weiter zu arbeiten, in welche ich besonders durch Valentin eingeführt worden war, der jetzt noch als Professor in Bern wirkt. Ich machte qaraus im Gespräche kein Hehl. „Sie kommen mir gerade recht", sagte Agassiz. „Wenn Sie Ihre Doktor- und Staatsprüfungen beendet haben, so kommen Sie zu mir herüber nach Neufchatel. Ich habe ein weitschichtiges Werk über die Süßwasserfische Mittel-Europa's begonnen, weiß aber nicht, wo Zeit hernehmen, um es weiter zu führen. Es fehlt mir Jemand, um die Anatomie und Entwickelungsgeschichte zu bearbeiten. Sie können mir helfen. An Material soll es nicht fehlen.

Gesagt, gethan. Mit Ende des Sommers 1839 zog ich in die Agassiz'sche Werkstätte in Neufchatel als Arbeiter ein.

Wohl eine Werkstätte und sogar in großartigem Style! In den Arbeitszimmern der Wohnung schafften Desor und ich als ständige Gesellen, während von Zeit zu Zeit der Eine oder der Andere zuging, so daß man kaum einen Wissenschaftsmann [der] Schweiz finden möchte von unserem Alter, der dort nicht eine Zeitlang zugebracht, irgend eine Arbeit vollendet oder den Stoff und Plan zu einer solchen vorbereitet hätte. Aber diese Arbeitszimmer waren nur der geringere Theil des Geschäftes. Nicht nur eine Druckerei, sondern eine ganze Lithographie hingen großentheils von unserer Thätigkeit ab. Zwei Zeichner waren beständig außer dem Hause beschäftigt: der eine, Dinckel, häufig abwesend auf Reisen in England, wo Agassiz bei der Durchforschung der Sammlungen ihm die Stücke bezeichnet hatte, welche er dann mit seltener Meisterschaft in Aquarell darstellte; der andere, ein geborener Neuenburger, Bourcart, der später Agassiz auch nach Amerika folgte. In einem Nebenhause saß ein alter, heruntergekommener Doctor der Medicin, der die Titel der Bücher und Abhandlungen, die Namen der zoologischen Classification aus dem gesammten Material auszog, daß Agassiz herbeizuschaffen wußte, zu einem großen Sammelwerke, das später unter dem Namen "Nomenclator zoologicus" gedruckt wurde. Ein wissenschaftlicher Famulus, anfangs nur Schreiber und Mädchen für Alles, der sich aber allmählich zu einem tüchtigen Zoologen heranbildete, gehörte zum Mobiliar der Werkstatt.

Man kann sich denken, daß die Räder eines so bedeutenden Getriebes nicht immer gut ineinander griffen. Die Druckerei verlangte Manuscript, die Lithographie Vorlagen; es war des Treibens und Drängens und damit auch des Schaffens für uns kein Ende — oft kaum die nöthige Zeit zum Untersuchen. Agassiz hatte immer neue Pläne, neue Aufgaben — jeder Gedanke, der ihm durch den Kopf fuhr, gestaltete sich zu einem großen Kupferwerke mit Hunderten von Tafeln in Folio, Hunderten von Bogen Text; darin war er Meister, ebenso wie im Herbeischaffen von Material von der Arbeit. Ganz Europa wußte er in Contribution zu setzen — oft standen die Kisten, die mit fieberhafter Ungeduld herbeigeschrieben wurden, Wochen und Monate lang, ehe sie nur aufgemacht wurden, weil unterdessen die Gegenstände, die sie enthielten, längst ihr Interesse verloren hatten und man mit einem andern Objekten beschäftigt war.

Wenn ich die zahlreichen Naturforscher durchmustere, die ich in meinem Leben kennen gelernt habe, so kann ich wohl sagen, daß Agassiz derjenige war, welcher von der Natur mit den reichsten Anlagen bedacht war, wenigstens für die beschreibende Zoologie. Er besaß einen unglaublich feinen Sinn für Formgestaltungen bis in die kleinsten Einzelnheiten hinein und ein riesiges Gedächtniß für dieselben. Beim Durchlaufen einer Sammlung, wo ein Anderer kaum Zeit hatte, zu sehen, ob irgend etwas Bemerkenswerthes vorhanden sei, hatte er schon mit sicherem Blicke herausgefunden, was ihm neu, was ihm bekannt war. In denjenigen Klassen, mit denen er sich besonders beschäftigt hatte, Fischen und Seeigeln, wußte er auf den ersten Blick zu sagen, wo und in welchem Museum er dieselben oder eine ähnliche Art vor langen Jahren gesehen hatte. Ein meist richtiger Instinkt leitete ihn augenblicklich zu den charakteristischen Eigenthümlichkeiten, die zur Klassification benutzt werden konnten.

Freilich verleitete diese Leichtigkeit auch zu mancher Flüchtigkeit. Ich erinnere mich, daß Desor einmal in die Beschreibung eines fossilen Fisches den Satz einfließen ließ: „Dieser Fisch unterscheidet sich von der ihm nachstehenden Art dadurch, daß er den Kopf da hat, wo der andere den Schwanz zeigt." Das Manuskript wanderte in die Druckerei, der Bogen kam zurück, wurde corrigirt, revidirt, abgezogen, und schließlich mußte man ihn umdrucken lassen! Keiner der Revisoren, auch Agassiz selbst nicht, hatte beim Lesen den enormen Blödsinn bemerkt!

Seine eigentliche naturwissenschaftliche Schule hatte Agassiz in München durchgemacht, wo damals Döllinger, Spix, Martius und Andere wirkten. Er hatte dort mit dem später verlotterten, aber nicht gedankenlosen Karl Schimper und dem Professor der Botanik in Berlin Alexander Braun ein inniges Freundschaftsbündniß geschlossen, das auch dadurch Ausdruck fand, daß Schimper und Agassiz sich mit zwei Schwestern Braun's verlobten und Agassiz später auch seine Braut heimführte.

Wenn Etwas, so hat den ausgebreiteten Ruf von Agassiz hauptsächlich die glückliche Wahl der Stoffe, die er zur Bearbeitung vornahm, gefördert. In München hatte er sich auf das Studium der Fische geworfen; nach dem Tode von Spix wurde ihm die Bearbeitung der in Brasilien von diesem und von Martius gesammelten Fische übertragen, und hier schon fand sich des Neuen viel, bei dessen Benennung er seine Gabe, wohlklingende und bezeichnende Namen zu erfinden, bethätigen konnte. Hierdurch wurde er auf die fossilen Fische gelenkt—ein durchaus unbearbeitetes Feld, da mit Ausnahme eines Kupferwerkes von Volta (einem Bruder des berühmten Physikers, wenn ich nicht irre) über die bekannte, so reiche Lagerstätte des Monte Bolca bei Verona, das hinsichtlich seines Textes sehr dürftig war, und einer kleinen Schrift von Blainville nichts Bemerkenswerthes darüber geschaffen worden war. Hier war nun Agassiz ganz auf seinem Terrain — fast Alles war neu; England namentlich, wo er durch die seltene Leichtigkeit, mit der er fremde Sprachen sich aneignete, durch seine Liebenswürdigkeit und sein vollständiges Eingehen in die Sitten und Gebräuche, ja selbst die Eigenheiten und Schrullen Anderer sich zahlreiche Freunde erworben hatte, lieferte Massen von Material. In Schlössern und Landsitzen wurde es förmlich Mode, Sammlungen versteinerter Fische anzulegen und Lord Cole (später Earl Enniskillen), Sir Francis Egerton, Lady Gordon Cumming hatten oft Monate lang den Maler Dinckel im Hause, um ihre reichen Schätze abkonterfeien und nach Neuenburg schicken zu lassen. Das große Werk über die fossilen Fische überhaupt und die nachfolgende Monographie der Fische des alten rothen Sandsteines aus dem Devonischen System begründeten dann auch hauptsächlich seinen ersten Ruhm, während er durch die Untersuchungen über die Gletscher ganz besonders dem größeren Publikum bekannt wurde.

— **Affenvogt und Agassiz.** Wir theilten neulich einige interessante Notizen mit, die Carl Vogt in Genf über Agassiz publizirt hat. Der erste Artikel Vogts, dem wir dieselben entnommen hatten, war so übel nicht. In einem zweiten macht er den armen Agassiz dagegen ganz erbärmlich herunter. Agassiz habe seinen ganzen Ruhm eigentlich ihm—Carl Vogt—nebst Desor und Greßly zu danken. Diese drei Herrn hätten die Arbeit gethan und Agassiz dafür den Lohn empfangen. Neuchatel habe Agassiz hauptsächlich Schulden halber verlassen. In Amerika endlich sei ein vollkommener Faulpelz und Humbugger aus ihm geworden. Folgendes sind Vogts Schlußworte: „Doch genug. Es wird mir Mancher verargen, diese Zeilen geschrieben zu haben. Man soll ja von den Todten nur gutes reden. Aber es gibt Laufbahnen, die berechnet und verstanden sein wollen. Ich kenne nichts Schöneres, als wenn Männer, die Riesiges geleistet haben, ihre hohe Stellung dazu benützen, selbstlos die Jugend zu sich heranzuziehen und ihr zu geben, statt von ihr zu nehmen. Gerade deßhalb muß es auch erlaubt sein, an Beispielen Anderer zu warnen, die auf Abwege zu gerathen im Begriffe stehen und Solcher gibt es in den wissenschaftlichen Kreisen mehr, als man gewöhnlich anzunehmen pflegt."

8. *Cave at Kutztown, Berks Co., Pa.*—About four miles from Kutztown, Pennsylvania, a cave has been recently discovered which affords handsome stalactites, equal, according to a letter from H. W. Hollenbush, to those of Mammoth Cave.

9. *Aurora Australis.*—The Aurora Australis was very bright at Melbourne, in Victoria, March 9th.—*Monthly Record of the Melbourne Observatory*, for March, 1873.

Transactions of the Connecticut Academy of Arts and Sciences. Vol. II, Part 2, pp. 209 to 410, 8vo, with 10 plates. New Haven, 1873.

Proceedings of the Academy of Sciences of Philadelphia. Part II. 1873.—Philadelphia, 1873.

Proceedings of the California Academy of Sciences. Vol. V, Part 1. 96 pp. with 2 plates. San Francisco, 1873.

Bulletin of the Buffalo Society of Natural Sciences. Vol. I, No. 3. Contains several zoölogical papers by Aug. R. Grote, and one on the Statistics and Distribution of North American Lichens, by Henry Willey.

Fifth Annual Report of the Trustees of the Peabody Academy of Science, at Salem, Mass., for the year 1872. 136 pp. 8vo. Contains several Entomological papers by A. S. Packard, Jr., also on the Cave Fauna of Indiana, by Mr. Packard; and a Record of American Entomology for 1872.

Investigation of the Orbit of Uranus, with general tables of the Moon, by Simon Newcomb, Prof. Mathematics, U. S. Navy. 288 pp. 4to. Smithsonian Contributions to Knowledge, No. 262.

On the Corrosion and Fouling of Iron Ships, by Robert Mallet, Esq., C.E., F.R.S., 64 pp. 4to. London, 1873.

Introductory Text-book of Physical Geography, by David Page; sixth ed. 232 pp. 12mo. Edinburgh and London, 1873. (Wm. Blackwood & Sons). Very poor in its geological chapter, and not very good in any other part.

The Galvanometer and its uses. A Manual for electricians and students, by C. H. Hawkins. 76 pp. 12mo (in pocket book form), with illustrations. New York, 1873. (D. Van Nostrand). A very full and convenient little manual.

A Catechism of High Pressure Steam Engines, including the modeling, constructing running, and management of steam engines and steam boilers, by Stephen Roper, Engineer. 218 pp. 12mo, with illustrations. Philadelphia, 1874. (Claxton, Remsen & Haffelfinger).

Mind and Body: The Theories of their Relations, by Alexander Bain, LL.D., Prof. Logic, Univ. of Aberdeen. 196 pp. 12mo. New York, 1873. Appleton's International Scientific Series.

OBITUARY.

Agassiz.—The death of Agassiz occurred soon after ten o'clock on Sunday night, December 14th, at his own house in Cambridge, after an illness which confined him only one week. He was attended by the best medical skill. His family physician, Dr. Morrill Wyman, and his old friend, Dr. Brown Sequard, were constantly with him. He died from nervous prostration, resulting in an attack of paralysis, affecting the respiratory muscles, and especially the pharynx.* His last public effort was an address before the Massachusetts State Board of Agriculture, at Fitchburgh, on Tuesday evening, December 2d, four days only before his prostration. He met his students on the 5th; and on Saturday, the 6th, while at work in the Museum of Comparative Zoölogy, he

* The details of the autopsy, which was made with great care, will be published hereafter. The base of the cerebellum was the seat of disease. The brain weighed entire about 1600 grams; free from blood and fluid, 1500 grams; considerably more than the normal average weight of the human brain.

was overcome with a sense of debility, and retired unaided to his house and his bed, never to leave them. He lectured not only with ease, before the State Board of Agriculture, but with an unwonted energy, even for him; an evidence, no doubt, of cerebral disturbance, of which many other proofs are known. But, the next day, the bad effects of his over-exertion were so evident that, by command of his physician, he relinquished an engagement to lecture at New Haven on the 8th.

Born on the 28th of May, 1807, Agassiz had attained only his 67th year. He was in his fortieth year when, in Oct., 1846, he landed at Boston, in the maturity of his reputation and of his remarkable intellectual powers. He came here at the suggestion of Baron Von Humboldt, who secured for his study of American geology and natural history a liberal appropriation from the King of Prussia. He first announced his intention to visit the United States in a letter to Prof. Silliman, dated at Neufchatel, Oct. 20, 1845. How great the change since, in his relations to the people and scientific men of America! He then wrote as follows: "After having finished all these numerous works in the study, I have truly need to replenish myself anew in the fields; and I hope to reap a rich harvest in your country. I know not how to thank you enough, my dear Sir, for all the information you have taken the trouble to send me; it has already been of great use to me in preparing myself for such a journey, and will serve me as a guide on my arrival in your country, where I have no relations or acquaintance among men of science. * * You are the only person in the United States with whom I maintain a correspondence. I wrote once to ——, and once to ——, without receiving any reply from the latter. * * All that you say to me of American naturalists and of their kindness, enchants me, and the time spent in America will surely be to me one of the happiest and most instructive epochs of my life." In a subsequent letter (dated Feb. 1st, 1846), he adds: "There is, in the prodigious activity of the Americans, something intoxicating, which has inspired me; and already I feel my youth renewed, in the anticipated contact with the noted men of your young and glorious republic." * * "Knowing the great desire I had to visit your country, and the impossibility of doing it at my own expense, his Excellency, the Baron von Humboldt, who has always treated me as a friend, and whose good counsels have been to me like those of a father, proposed to the King of Prussia to give me the necessary funds for the journey, which his Majesty granted to me in the most generous manner, furnishing me with a sum sufficient for a journey of two years, traveling alone. However, desiring to profit by this opportunity to gather as much as possible of the materials of the natural history of the United States, my intention is to have a *preparateur* and draughtsman accompany me, so as to have drawn from life all the fishes of your rivers and lakes, which have not yet been properly represented; and also the mollusks of your coasts, which have not been sufficiently studied. But, to provide for the extra expense, I shall be obliged to live very economically, and in a manner little in accordance with the royal munificence which has furnished the means of making this journey. * * My sphere is entirely circumscribed by the scientific world, and all my ambition is limited to being useful to the branch of science which I particularly cultivate. With all this, I am no misanthrope; but I learned early that, where one has no fortune, one cannot serve Science and at the same time live in the world. If I have been able to produce numerous expensive publications, it has been only by following this system of economy and voluntary seclusion; and the results which I have obtained thus far have rewarded me so well for the privations which I have suffered, that I have no temptation to adopt another style of life, even should I have hereafter, and especially in your country, more trouble than I have had to sustain it in my own."

Recalling his wonderful success and influence in America, how interesting to read now these early utterances of his, in anticipation of a voyage which was destined to change his country for life, and lead to achievements so important to the cause of science and humanity, and so greatly transcending his utmost hopes! In full sympathy with all liberal and truly progressive ideas, he was not more ready to adopt the United States as his future home, after a brief residence, than this country was to accept and honor him. This decision was favored by the political commotions which, in 1848, unsettled everything in Europe. The single event, however, which perhaps more than any other determined him to remain in America, was an invitation from the late Chief of the United States Coast Survey, Prof. A. D. Bache, to accept the hospitalities of the steamers in that service, to explore the coasts of the United States on both sides of the continent. How joyously he accepted an invitation, so far exceeding his wildest dreams, is well known; and how rich have been the fruits thus gleaned for science is known as yet only in part, since the record of his last great exploration on board the Hassler, along both sides of the continent of South America and on the Pacific shores of Central America and the United States, remains yet to be published. This last great exploration was carried out in consequence of the enlightened policy of the present Chief of the Coast Survey, Prof. B. Peirce, in furtherance of the designs of his honored predecessor.

Of Agassiz's incessant labors in the cause of science, and his vast performances, especially since he made this country his home, it is not now our purpose to speak. Fitting record will be made of all these hereafter. Not this nation only, but the world, has suffered a great loss. More than any man since Cuvier and Von Humboldt, has he been known over the whole world. His fame arose alike from the great number and value of his original investigations and publications, from his ability as a philosopher, and from his power of inspiring others with his own enthusiasm. His life in the United States has awakened in thousands a zeal for the prosecution of scientific research, and beyond any other cause has promoted, and to a large degree created, that wonderful activity which, in twenty-five years, has placed this country,—before without a museum of natural history, a zoological laboratory, or a well organized Scientific school—in the front rank of scientific activity.

Long have we dreaded the sad event which we now record. Many years since, the splendid physique of Agassiz showed evidence that his prodigious labors were overcoming his elasticity. His herculean strength, which had made him a stranger to fatigue of body or mind, yielded to the severer tax of the American climate, and the incessant growing demands upon him from every source. His life and strength were renewed by his long voyage to San Francisco, in the Hassler; but both he and his friends have recognized the fact that to labor with his former activity was impossible and forbidden. Yet to live was for him, unavoidably, to labor; and to die in the harness, rather than to live after the power to serve his fellow men was passed, his aspiration.

An excellent sketch of Agassiz's life and labors, prior to 1860, will be found in the New American Cyclopedia, under his name; and a full list of his publications down to 1866, is contained in the Royal Society's Catalogue of Scientific Works.

His funeral was attended on the 18th of December, from Appleton Chapel at Harvard University, without ceremony, and in a touching simplicity of style quite in harmony with his life, by a vast assembly of mourning friends from Boston and many neighboring and distant cities. The flags of the municipality of Boston were hung at half mast; and the bells were tolled during the obsequies. No eulogy was pronounced: the voice of the officiating clergyman broke the silence with the words: "I am the resurrection and the life." To the solemn music of the "Dead March in Saul," the family and a few near friends, with the University authorities, left the chapel for Mount Auburn Cemetery, where now rests, by the side of his much loved friend, President Felton, all that is mortal of Louis John Rudolph Agassiz.

Agassiz's death cuts short his discussion of the doctrine of "Evolution and Permanence of Types," the first paper of which appeared in the Atlantic Monthly for the month of December. How like a voice from another world sound now these words concluding his summary of Darwin's publications: "I can only rejoice that the discussion has taken this turn, much as I dissent from the treatment of the subject. It cannot be too soon understood that science is one, and that whether we investigate language, philosophy, theology, history, or physics, we are dealing with the same problem, culminating in the knowledge of ourselves. Speech is known only in connection with the organs of man, thought in connection with his brain, religion as the expression of his aspirations, history as the record of his deeds, and physical science as the law under which he lives. Philosophers and theologians have yet to learn that a physical fact is as sacred as a moral principle. Our own nature demands from us this double allegiance." s.

Dr. Karl Friedrich Naumann, the eminent crystallographer and mineralogist, died at Leipzig on the 26th of November.

APPENDIX.

ART. XII.—*On the Structure and Affinities of the Brontotheridæ*; by O. C. MARSH. (With two plates.)

THE Miocene deposits on the eastern slope of the Rocky Mountains contain the remains of a group of gigantic mammals, of much interest, which have been named by the writer, *Brontotheridæ*.* Although these animals are less remarkable than the *Dinocerata* of the Eocene,† which they seem to have replaced, they equalled them in size, and resembled them in several important features, notably in the structure of the feet, and in having the head armed with a pair of powerful horns. The general structure of the group, however, clearly indicates that they do not belong in the order *Dinocerata*, but should be placed with the Perissodactyls, in which they form a well-marked family.

The more prominent characters of this family were pointed out by the writer in describing *Brontotherium gigas* Marsh, the type species, and others had been previously mentioned by Dr. Leidy in his descriptions of *Titanotherium Proutii*.‡ The skull of the latter genus is not known, but there can now be no reasonable doubt that it was furnished with horns, in some respects similar to those of *Brontotherium* (Plates I and II). The possibility of this was originally suggested by Dr. Leidy,§ and in his latest work he has figured a horn-core from the same deposits which yielded the *Titanotherium* remains.‖ The fragmentary specimen described by Dr. Leidy as *Megacerops Coloradensis*,¶ probably belongs in the same family, but until additional remains are found this point cannot be decided. The supposed genera *Symborodon* and *Miobasileus*, recently indicated by Prof. Cope (Am. Nat., vii, p. 753), belong to this group. The former is generically identical with *Brontotherium*, the reputed absence of lower incisors being evidently due either to age, or to imperfect specimens. *Miobasileus* is apparently the same genus, and hence both names should be regarded as synonyms of *Brontotherium*.

* This Journal, vol. v, p. 486, June, 1873.
† Loc. cit., p. 117, Feb., 1873.
‡ Extinct Mammalia, p. 206, 1869.
§ Loc. cit., p. 216.
‖ Extinct Vertebrate Fauna, Pl. XXVIII, fig. 3, 1873.
¶ Proceedings Phil. Acad., 1870, p. i, and Extinct Vertebrate Fauna, p. 239.

Among the more marked characters of the *Brontotheridæ*, which readily distinguish them from the *Rhinocerotidæ*, apparently their near allies, may be mentioned the following:—There are four short and thick toes in the manus, and three in the pes. The skull supports a pair of large horn-cores, placed transversely, as in modern Artiodactyls.* There are well developed canine teeth in both jaws. The molar teeth, above and below, are not of the *Rhinoceros* type, but resemble those of *Chalicotherium.*

The general characters of the *Brontotheridæ* are fully shown in a large series of specimens in the Yale College Museum. The cranial structure of *Brontotherium*, the type genus, is well illustrated in the nearly perfect skull of *B. ingens* Marsh (Plates I and II), described in this article. The only other genus of the group known with certainty is *Titanotherium* of Leidy (*Menodus* Pomel), which, according to the descriptions of that author, differed essentially in having four lower premolars, and in the absence of a third trochanter on the femur. Less important differences are seen in the composition of the teeth, and in the diastema between the upper canine and first premolar.

The skull in *Brontotherium* is elongated, and resembles in its general features that of *Rhinoceros.* The occipital region is greatly extended vertically, and deeply concave posteriorly. The brain cavity is unusually contracted. The vertex is concave longitudinally, and convex transversely (Plates I and II). The zygomatic arches are massive, and much expanded. The orbit is small, and continuous with the elongated temporal fossa. The nasals are greatly developed, and firmly coössified. They support entirely, or nearly so, the large divergent horn-cores. Their anterior extremities are produced, and overhang the large narial orifice. The premaxillaries are diminutive, and do not extend forward so far as the end of the nasals. The palate is deeply arched above, especially between the premolars. The posterior nares extend forward nearly to the front of the last molar. The lachrymal forms the anterior margin of the orbit. The malar extends forward beyond the lower margin of the orbit. The infra-orbital foramen is large, and situated well forward. The zygomatic process of the squamosal is elevated, and incurved above. There is a large post-glenoid process, and a massive, and somewhat shorter paroccipital process (Plate I). The posttympanic process of the squamosal is large, and quite external to the paroccipital process. The occipital condyles are large, and well separated.

* *Rhinoceros pleuroceros* Duv., from the Miocene of France, has a transverse pair of small horn-cores on the nasals, not unlike those in *Dinoceras*. *R. minutus* Cuv has somewhat similar processes.

The mandible has a wide condyle, and a slender coronoid process. The angle is rounded, and slightly produced downward. The symphysis is depressed, elongated, very shallow in front, and completely ossified.

The dental formula of *Brontotherium* is as follows:—

$$\text{Incisors, } \frac{2}{2}; \text{ canines, } \frac{1}{1}; \text{ premolars, } \frac{4}{3}; \text{ molars, } \frac{3}{3} \times 2 = 38.$$

The upper incisors are quite small. The canine is short and stout, and placed close to the first premolar. The latter is proportionally much larger than the corresponding tooth in *Titanotherium.* The upper premolars have all essentially the same structure, viz: two external connate cusps, with their outer faces nearly plane, and two inner cones closely united. The anterior cone is connected with the opposite outer cusp by a transverse ridge, which has behind it an elongated depression, more or less divided by projections from the outer posterior cusp. In the upper true molars, the external cusps have their outer surfaces deeply concave, while the inner cones are low and separate. The lower incisors were small, and evidently of little use. The two next the symphysis were separated from each other. One specimen in the Yale Museum has the crown hemispherical in form The lower incisors are not unfrequently wanting, and in old animals the alveoli may, perhaps, disappear. Careful examination, however, will usually show indications of them. The lower canine is of moderate size, and separated from the premolars by a short diastema. The lower molars are of the *Palæotherium* type, and agree essentially with those of *Titanotherium.*

The head in *Brontotherium* was declined when in its natural position. The neck was stout, and of moderate length. The cervical and most of the dorsal vertebræ are distinctly opisthocœlous. The latter are in general elevated. The atlas is large, and much expanded transversely. The axis is massive, and has its anterior articular faces much broader than in the *Dinocerata.* The odontoid process was stout and conical. The transverse process was small, and apparently imperforate. The posterior articular face is concave, and oblique. The epiphyses of the vertebræ are loosely united in most specimens, as in the Proboscidians. The caudal vertebræ preserved indicate a long and slender tail.

The limbs of the *Brontotheridæ* were intermediate in proportion between those of the Elephant and the Rhinoceros. The humerus is stout, and its entire distal end is occupied by the articulation. The olecranon cavity is shallow, and the condylar ridge similar to that of the Elephant, but not continued so far up the shaft. The ulna has its olecranon portion much compressed. Its distal end is much smaller than in *Rhinoceros,* and has no articular face for the lunar. The radius is stout, and its distal end expanded. The carpal bones form interlocking series. They are shorter than in *Rhinoceros*, and support four well developed toes of nearly equal size. The metacarpal bones are shorter than those of the *Rhinoceros*, the first phalanges longer, and the second series shorter. The ungual phalanges are short and tubercular, as in the Elephant.

The femur has a small third trochanter, and its head a deep pit for the round ligament. At the distal end, the anterior articular surface is narrow, and the two edges are of nearly equal prominence, as in the Tapir. There is a small fossa on the posterior side above the outer condyle. The tibia is stout, and has a distinct spine. The fibula is entire, but quite slender. The astragalus is shorter than in the Rhinoceros, and the superior groove more oblique. There is a deep pit near the center of the outer surface. The cuboid face is larger than in *Rhinoceros*. The navicular has its distal facets subequal. There were three toes of nearly equal size in the pes, the first and fifth being entirely wanting.

In comparing the *Brontotheridæ* with the equally gigantic *Dinocerata* of the Eocene, several striking points of resemblance will be at once noticed: especially the presence of horns in transverse pairs; the general structure of the limbs and feet; and particularly the short and thick toes. The differences, however, between these two groups are still more marked. In the *Brontotheridæ* there is but a single pair of horn-cores, and no crest around the vertex. The structure and number of the teeth are quite different, while the small canines and huge molars contrast strongly with the elongated canine tusks, and diminutive molars of the *Dinocerata*. The latter, moreover, have two very large dependent processes on each ramus of the mandible; the cervical vertebræ flat; the femur without a third trochanter; and an additional toe in each foot.

Among the features which this group shares with the *Proboscidea* may be mentioned: the superior extension of the condylar ridge of the humerus; the short thick toes; and the late union of the epiphyses with the centra of the vertebræ. The last character appears to belong especially to mammals of very large size, and probably indicates late maturity, and great longevity.

The preceding description makes it evident that the *Brontotheridæ* constitute a very distinct family of the *Perissodactyla*. While retaining some prominent features of their Eocene predecessors, the *Dinocerata*, they are more nearly related to the Rhinoceros family, and at the same time they have some characters allying them to the *Proboscidea*, which replace them in the succeeding, Pliocene period.

All the known remains of the *Brontotheridæ* are from east of the Rocky Mountains, in the Miocene beds of Dakota, Nebraska, Wyoming and Colorado. The specimens here described are mainly from localities in the "Bad lands" of Colorado, which were discovered and explored by the writer in the summer of 1870.*

Brontotherium ingens, sp. nov.

A new and well marked species of *Brontotherium* is represented in the Yale College Museum by a skull, nearly perfect, and other characteristic remains. The specimens preserved indicate that the animals to which they pertained were much the largest of the group, nearly or quite equalling the elephant in bulk, and far exceeding in size any known Perissodactyls living or fossil.

The skull in the type specimen of the species is well represented in the accompanying plates, and its general characters have already been given. The most striking peculiarity of this cranium is the pair of huge horn-cores on the nasals. They are about eight inches in length, and extend upward and outward. They are triangular at the base, with the broadest face external. The two inner faces of each core are separated by a ridge, which is continued to the median line. The upper part of the horn-cores is rugose, and the base contains large air cavities. The free extremities of the nasals are coössified, and much elongated. They are rounded in front, slightly decurved, and the surface at the end is rugose. The orbit is of moderate size, and looks forward, outward, and upward. The lachrymal foramen is small, and ovate in outline. Just below it, there is a depression of similar form. The infra-orbital foramen is unusually large. There is no post-orbital process. The zygomatic arches are massive, and the squamosal portion widely expanded. The temporal fossa extends far backward, and has over its posterior portion an obtuse ridge. The occipital condyles are very large, wide apart, and extend slightly behind the supra-occipital crest. The paroccipital process of the squamosal is elongate, and its anterior face concave. The postglenoid process is very large, much extended transversely, and is longer than the paroccipital process.

The premaxillaries in this cranium are imperfect, and the incisors wanting. The canines, also, are not entire, but they were only of moderate size, and in close proximity to the first premolar. This tooth had two fangs, and resembled the other premolars. All of these have a strong inner basal ridge. The crowns are more nearly square than in *Titanotherium Proutii* Leidy. The upper true molars are very large, the last especially

* This Journal, II, vol. 1, p. 292, Sept., 1870.

so. It resembles the corresponding tooth in *T. Proutii*, but the inner posterior angle of the crown is much more developed.

The limbs in this species were shorter than those in the existing elephants, which, in form of body, it doubtless resembled. The huge divergent horns, and the absence of tusks, gave the head a very different appearance. The wide narial opening, the rugose extremities of the nasals, and the very large infraorbital foramen, naturally suggest that there must have been an elongated, flexible nose, possibly as extensive as in the Tapir. That there was no long proboscis, as in the Elephant, is indicated with equal certainty by the length of the head and neck, which renders such an organ unnecessary.

The principal dimensions of the skull represented in plates I and II are as follows:—

Measurements.

Length of skull from occipital condyles to end of nasals (36 inches),	915·mm
Distance from posterior margin of occipital crest to front of horn-core,	762·
Distance on median line from occipital crest to end of nasals,	762·
Width between extremities of horn-cores (20 inches),	507·
Expanse of zygomatic arches,	558·
Least distance across vertex,	157·
Space occupied by four upper premolars,	162·
Space occupied by three upper true molars,	266·
Antero-posterior diameter of last upper molar, on outside,	117·
Antero-posterior diameter, through center,	112·
Transverse diameter,	114·
Antero-posterior diameter of fourth upper premolar,	53·
Transverse diameter,	69·
Antero-posterior diameter of third upper premolar,	48·
Antero-posterior diameter of second upper premolar,	37·
Antero-posterior diameter of first upper premolar,	26·5
Width across palate between second premolars,	55·
Width across palate between last upper molars,	115·
Space between outer faces of last upper molars,	330·
Greatest height of zygoma,	145·
Height of zygoma at anterior extremity of malar suture,	90·
Greatest diameter of occipital condyle,	120·
Least diameter,	75·
Distance between outer margins of occipital condyles,	204·

All the known remains of this species are from the Miocene of Colorado, and are preserved in the Yale Museum.

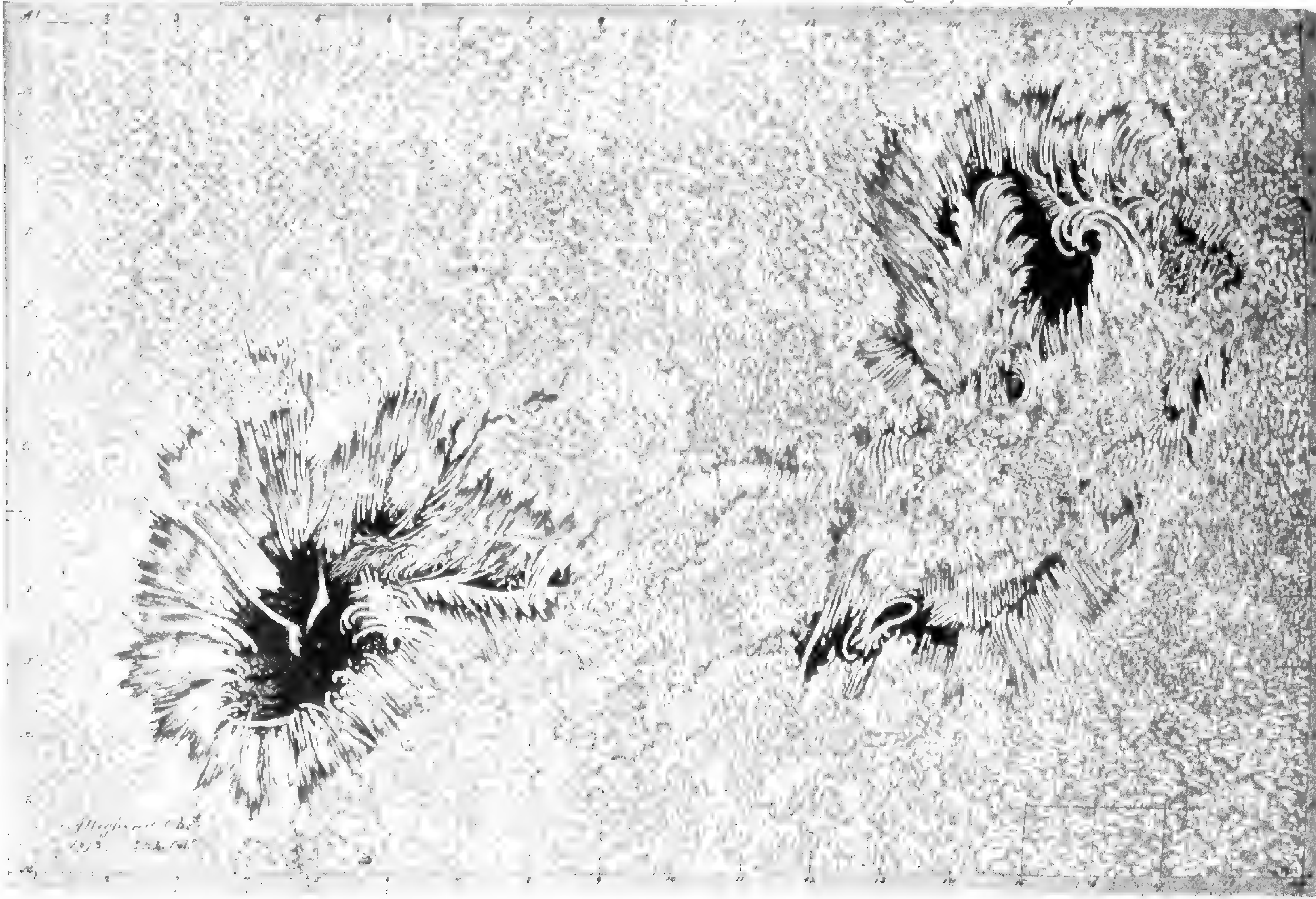
Yale College, Dec. 24th, 1873.

EXPLANATION OF PLATES.

Plate I. *Brontotherium ingens* Marsh. Side view. One-sixth natural size.
Plate II. *Brontotherium ingens* Marsh. Top view. One-sixth natural size.

BRONTOTHERIUM

Studies of the minute structure of the Solar Photosphere, made at the Allegheny Observatory.



S. P. LANGLEY, DEL. 1873.

E. BIERSTADT ALBERTYPE

THE

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[THIRD SERIES.]

ART. XIII.—*On the Minute Structure of the Solar Photosphere;* by S. P. LANGLEY.

IT will be within the memory of all concerned in such studies, that when, in 1861, Mr. Nasmyth announced the discovery of what he called the "willow-leaf" structure of the solar surface, a lively interest was excited, and that a subsequent discussion arose in which some eminent observers took part. It will be remembered also what a diversity of opinion was exhibited, not only as to the nature of the structure, but as to the fact of its existence, concerning which the most contradictory opinions were emitted. It was pointed out that Mr. Nasmyth's estimate of the size of these bodies was inconsistent with the difficulty which was found in seeing them. Mr. Dawes, than whom no one stood higher as an observer, denied their existence. Father Secchi doubted the accuracy of the description, while asserting that he had seen multitudes of small discrete bodies of much less size than the so-called willow leaves. Mr. Stone and Mr. Donkin found the minute components of the photosphere to resemble rice-grains, and so on with others. As each observer maintained a different opinion, in spite of the interest of the discussion, no conclusive result was reached; for it was a peculiar feature of this remarkable controversy that it did not arise concerning an interpretation of fact, but as to the reality of the fact itself, concerning which, with the best instruments in practised hands, it seemed difficult to find any two observers to agree. The state of our present knowledge on the point can hardly be considered satisfactory, for no telescopic observations of special value have been since added of which I am aware, with the exception of some early ones by Lockyer and Huggins (a paper by the latter being accompanied by a suggestive drawing),* and of some illustrated by Secchi's excellent sketches. The difficulties of observation are in fact extreme, they are enhanced by want of a precise nomenclature, and their elucidation is not easy without elaborate drawings. The present article, which partly anticipates a prospective and completer publication on the part of the Allegheny Observatory, is meant as a help to their removal, and as a contribution of material for a judgment upon the theories of the solar circulation due to Faye, Kirchoff, Lockyer, Secchi, Young, Zöllner, and other eminent students of Solar Physics. As it is based only upon direct telescopic study of the minute components of the photosphere, it will offer a distinct point of view from that taken by the spectroscopist, and though therefore incomplete, its testimony to the action of solar currents will yet have a certain value from the fact of this independence.

Most of the minuter phenomena to be described are unrecognizable except with large apertures, which, in spite of the abundant light, are indispensable for reducing irradiation. That of the equatorial of the Allegheny Observatory is thirteen inches, but when we use so large an instrument on the sun, we find two principal difficulties. The first, arising from the concentrated light, can be mitigated by optical aids. By the liberality of a citizen of Pittsburgh, the equatorial has been supplied with several special accessories for such study, the most essential of which is the polarizing eye-piece, which, in the form devised and employed here, presents a solar image free from color and of any brightness desired. To secure the rapidity needed in sketching objects whose forms are so changeable without sacrificing accuracy, Mr. Rogers, of the Harvard College Observatory, has had the goodness to rule for me one of his very exact reticules on thin glass, which for the present purpose is divided by faint lines into squares, the side of each being one one-hundredth of an inch, the value of which in the solar focus is 11″·55. The Filar micrometer is of course also employed where its use is appropriate.

The second and more formidable difficulty arises from the disturbance of our own atmosphere, and for this there is no present remedy but assiduity and patience.

It may be stated generally that it will be useless to look for the minuter details described, whatever the power of the telescope, save in exceptionally good definition. In such an investigation, drawings are at present indispensable. Photography in the hands of Messrs. De la Rue and others has been of great service in furnishing unquestionable data for the student of the

* See Monthly Notices Roy. Ast. Soc.; also, Proctor, "The Sun."

laws which govern the solar rotation and the motions of the spots in longitude and latitude, and all are familiar with the results obtained by Mr. Rutherfurd; but however excellent these are, they show that photography in the most skillful hands is at present incompetent to seize multitudes of details which the eye recognizes. Drawings, then, are necessary, but rather such as imitate the fidelity of the topographical draughtsman, than such as aim chiefly at striking pictorial effect; and in the absence of the skill of an artist, I am used to try to secure accuracy by reducing everything as far as is possible to micrometric measurement.

Before we turn with these aids to the study of the photosphere, it will be well to describe briefly appearances presented by the solar surface in telescopes of moderate size.

Here we see a disk of nearly uniform brightness, which is yet sensibly darker near the circumference than at the center. Usually seen relieved against this gray and near the edges, are elongated and irregular white patches (*faculæ*), and at certain epochs trains of spots are scattered across the disk in two principal zones equidistant from the solar equator. On attentive examination it is further seen that the surface of the sun everywhere—even near the center and where commonly neither faculæ nor spots are visible—is not absolutely uniform, but is made up of fleecy clouds, whose outlines are all but indistinguishable. The appearance of snow flakes which have fallen sparsely upon a white cloth, partly renders the impression, but no strictly adequate comparison can perhaps be found, as under more painstaking scrutiny, we discern numerous faint dots on the white ground, which seem to aid in producing the impression of a moss-like structure in the clouds, still more delicate, and whose faint intricate outlines tease the eye, which can neither definitely follow them, nor analyze the source of its impression of their existence.

These appearances have been mentioned, lest they should be confounded in any way with the far minuter structure now to be described.

Under high powers used in favorable moments, the surface of any one of the fleecy patches is resolved into a congeries of small, intensely bright bodies, irregularly distributed, which seem to be suspended in a comparatively dark medium, and whose definiteness of size and outline, although not absolute, is yet striking by contrast with the vagueness of the cloud-forms seen before, and which we now perceive to be due to their aggregation. The "dots" seen before are considerable openings caused by the *absence* of the white nodules at certain points, and the consequent exposure of the gray medium which forms the general background. These openings have been called pores;

their variety of size makes any measurements nearly valueless, though we may estimate in a very rough way the diameter of the more conspicuous at from 2″ to 4″. The bright nodules are themselves not uniformly bright, (some being notably more brilliant than their fellows and even unequally bright in portions of the same nodule), neither are they uniform in shape. They have just been spoken of as relatively definite in outline, but this outline is commonly found to be irregular on minute study, while it yet affects, as a whole, an elongated or oval contour. Mr. Stone has called them rice-grains, a term only descriptive of their appearance with an aperture of three to four inches, but which I will use provisionally. It depicts their whiteness, their relative individuality, and their approximate form, but not their irregular outline, nor a certain tendency to foliate structure which is characteristic of them, and which has not been sufficiently remarked upon. This irregularity and diversity of outline have been already observed by Mr. Huggins. Estimates of the mean size of these bodies vary very widely. Probably Mr. Huggins has taken a judicious mean in averaging their longer diameter at 1″·5, and their shorter at 1″, while remarking that they are occasionally between 2″ and 3″ and sometimes less than 1″ in length.* Estimates of their number are few and more or less conjectural. Mr. Dunkin, using about four inches aperture, found between two and three hundred of them in a space 56″ by 48″. If we call the number two hundred and fifty, we have their average distance apart about 3·4′ $\left(=\sqrt{\frac{56\times 48}{250}}\right)$, which is certainly too great. In the almost total absence of micrometric determinations, the following, though imperfect, will have interest. With the Rogers micrometer and near the center of the sun, with a power of 240 and an aperture of 9 inches, 18 rice-grains were counted in one square (11″·6 on the side). In the next square there were 15, in the next 23. These differences are not so much due to imperfect estimation as to a real irregularity of distribution. On another occasion, with a higher power, 15 rice-grains were counted in a line whose length was 18″·87 and on an adjacent part of the disc, in the same length, 12. From the mean number in these squares and the value of the side of a square in arc, we deduce 2″·57 as the distance between the centers, while with the higher powers we obtain a value of but 1″·42, with every increase of telescopic power the number of minute bodies counted as rice-grains thus being

* It is well to remember that even upon this estimate each of these "minute" bodies is larger than Great Britain.

increased and the mean distance between their centers diminished.*

In moments of rarest definition I have resolved these "rice-grains" into minuter components, sensibly round, which are seen singly as points of light, and whose aggregation produces the "rice-grain" structure. These minutest bodies, which I will call *granules*,† it will appear subsequently can hardly equal 0″·3 in diameter, and are probably less. (Secchi is the only observer, as far as I know, who appears to have seen and measured them. He observed them in the edges of the pores, and reckons their size at ″·$\frac{1}{3}$ to ″·$\frac{1}{5}$, but does not estimate their number or point out their relations to the "rice-grains.") They are irregularly distributed, with a tendency to aggregation in little clusters (the clusters being the rice-grains), and their existence accounts for the diversity and irregularity in the outline of the latter, Mr. Huggins has acutely remarked upon, while it of course makes clear the reason of the apparent increase in the number of "rice-grains" with increasing telescopic power. The drawing gives in the two squares distinguished by a heavy outline, transcripts of specifically discriminated "rice grains," and their component granules, as they appeared projected upon the squares of the Rogers' reticule when powers of from four to eight hundred were advantageously used with the full aperture of thirteen inches. The granules are the minute bodies recognizable as forming the not very definite clusters. These clusters are, as I have said, the "rice-grains," which appear better defined with smaller apertures, but seen under such powers lose in part their individuality.‡ The drawing will help explain the difficulties in the measurement, and the varying estimates, for we see here that the "rice-grain" is scarcely an entity, but that the term (if still retained) should merely convey our recognition of the fact that there is a tendency in the granules to unite in clusters, and in this sense only I will continue to use it. The apparently vacant spaces may contain more or less of partly luminous granules, as I am inclined to believe they do, without being able to obtain certitude. Whether we consider the granules the luminous summits of ascending currents of gases dissociated at lower depths and becoming incandescent at the surface, or whatever physical

* There is no antecedent improbability in the idea that they are more numerous in certain latitudes than in others, but if there be a difference, it is inconspicuous.

† As this word is already in use, with another meaning, attention should be given to the restricted and definite significance which is here assigned to it.

‡ I have been led from several independent observations to estimate that the longer axes of the clusters lie in a majority of cases nearly parallel to the solar equator, and this, with certain appearances associated with the granules, makes me think that there is a *drift* of the whole photosphere in the same direction. At the same time, I wish to await more of the rare opportunities for these difficult measurements before announcing this as a fact not open to question.

theory we adopt, we may admit the contingency of a more general distribution than is at first apparent, while recognizing that we can number those distinctly visible, and can compute the area they expose, without fear that our estimate will induce material error from the neglect of the existence of other of these bodies relatively non-luminous, which with more powerful instruments might conceivably be discerned.

In fact, the prevalent impression that the brilliant bodies to which the photospheric light is chiefly due are so closely set that only minute dots or shades of thread-like narrowness appear between, is, I venture to state, incorrect. I hardly think it can be shared by one who, after his attention is directed to this point, has the opportunity of studying them under circumstances of reduced irradiation, when these bodies are seen to occupy the smaller portion of the area they at first appear to fill. Independent calculations will reduce this area still farther. The number of granules varies widely, there being commonly from three to ten to the rice-grain, while a count of individual granules with the highest powers gives from eighty to one hundred to each of the squares. More might doubtless be reckoned by powers which subdivided the granule, but this would not affect the estimate of their aggregate area. If, to allow the widest latitude for errors of observation, I assume that the granule may be as much as ″·4, and the number to the square two hundred, I still find that the properly luminous area is *less than one-fifth* of the solar surface.

We are now prepared to study the minute structure of the photosphere under another aspect, as it appears in the spots. It is impossible to make such a drawing as that here given from any single delineation, owing to the rapidity with which spots change their form. I have accordingly, while taking the general contour and many details from drawings of the great spot of March 5 and 6, 1873, added the results of numerous studies of detail in other spots, made during the past two years. Such a method has obvious drawbacks, in a liability to exhibit features individually true in a connection in which they would not be found in nature. There is no alternative, however, until solar photography has made further advances; and I have used my best pains to combine only such features as belong in organic connection. I have made it a rule to set down only so much as was unquestionably seen, and therefore to give nothing which was partly seen, partly inferred, and to make the annexed drawing as far as possible a faithful transcript of sketches taken at the telescope, and which were, whenever possible, completed and compared before leaving it.

To represent the gradations of light from the intensest splendor to the darkness of the nuclei, we have here only the limited range between a white and a black pigment. This almost compels partial falsity in the degrees of shade, and there is, for instance in the drawing, a relative exaggeration of the shade which marks the outer boundary of the penumbra, and without which the important details would be hardly visible. The drawing is crossed by fine lines which represent squares of the Rogers' reticule projected on the sun, and it will be convenient to remember that the side of each corresponds very nearly to a linear measure of 5,000 miles. The line marked H corresponds nearly to the trace of the ecliptic; lines parallel to it are lettered, and those perpendicular to it numbered, so that by J_{13}, for example, we may denote the part of the spot near the intersection of "J" and "13."

In approaching the spot, the photosphere becomes usually very slightly brighter, and it is more difficult to distinguish individual granules till just at the edge of the penumbra. Here the continuity of the photosphere is *suddenly* interrupted. The penumbra is usually darkest around this edge, the shade defining the granules; which here appear to be elongated, while some are apparently pulled out into long filaments, which cross the outer penumbral shade without a diminution of brilliancy. Then the penumbra grows brighter to the inner edge, but not with a uniform progression, there being rather a sudden increase of brightness at about half its width. This inner edge is usually (not invariably) the brightest part of it, and it is sometimes comparable in brilliancy to the photosphere. (The general description just given applies only to the normal type of spots, and has very wide exceptions.) The penumbra is all but wholly made up, as it appears on a first examination, of cloud-forms whose structure makes them seem like fagots or sheaves of some elongated objects. These sheaves Mr. Dawes has compared to bundles of thatch, the likeness being helped by what appear to be individual straws protruding beyond others over the penumbral shade. With further study, with the highest powers, Mr. Dawes' comparison does not quite hold. With these the penumbra is resolved into "filaments" of extreme tenuity, which by their aggregation make the "thatch," just as the minute granules of the photosphere compose the "rice-grains." These filaments I have observed to have a tendency to lie in sheets or folds, whose superposition causes different degrees of brightness, and gives the thatch aspect (G_4 to H_7), and there is also a resemblance (not shown in the drawing) at times to the appearance of water falling so thickly that it coheres in sheets or veils, such as are seen, for instance, in advance of the main body of the fall at Niagara, or even at moments in violent rain storms.

In the best definition I find that the normal darkness of the outer penumbra is nothing else than the darkness of the gray medium in which the granules float all over the sun, though much deeper tints are here and there found, which sometimes make the penumbra almost resolvable into a ring of little spots. Over this shade stretch here and there bright filaments, which are continuous with the granules of the photosphere ($K_3 . F_6$ to E_7 and elsewhere), *through* it are sometimes dimly traceable fila ments which apparently float at lower depths. It seems to me that there is no room for doubt, that "filaments" and "granules" are names for different aspects of the same thing; that filaments in reality are floating vertically all over the sun, their upper extremities appearing at the surface as granules; and that in the spots we only see the general structure of the photosphere, as if in section, owing to the filaments being here inclined. They are in the best definition very commonly observed to have a ragged outline near their extremities, like bearded grain, suggestive of the idea that they may be formed of the union of a still smaller order of their kind. They are not of strictly uniform size, but the larger ones usually give indications of resolvability.

It is practically impossible, in the brief intervals of perfect definition during which such work can be carried on, to so multiply micrometric measurements, that from their concordance any idea of their probable error is obtainable by the usual treatment. Measurements taken at different times, and on different parts of the penumbra, by counting the number of filaments in a given space, give from 0″·7 to 1″·0 as the average distance from center to center of parallel filaments separated by scarcely measurable intervals; at the same time that the distance in some parts is greater, it is in others much less. One example of these measurements will suffice.

To reach a satisfactory determination of the upper limit of the size of these threads at their extremity, ten very close filaments were counted upon one occasion, which were separated by lines of unequal though not measurable width. Three consecutive measurements with the Filar micrometer gave 5″·34, 5″·30, 5″·27, as the width of the whole ten, the mean being 5″·30. To consider the effect of irradiation, we may assume from experience and without fear of contradiction, that a telescope of thirteen inches aperture, and with a power of 500, could not, under the most favorable circumstances, completely separate two stars whose distance is less than ″·3, and that considering that these vividly irradiant filaments were not only clearly separated, but that some of the divisions were wider than others, we must conclude that the unknown intervals which separate them are not *less* than ″·3. The sum of the nine interspaces is then not less that 2″·7, and subtracting this from 5″·3 we have 2″·6, as the most that can be assigned to the ten filaments, giving 0″·26 as the upper limit for the width of those under examination. But filaments are sometimes visible on the umbra so attenuated that they seem like threads of gossamer, and which, if they have the same intrinsic brilliancy as those measured, are demonstrably not over ″·03 in diameter, and of course, apart from their irradiation, far beyond the reach of the most powerful telescope. Their appearance is somewhat rare, but I have studied it in several cases; between H_5–I_6 will be found an illustration, which, however, gives an inadequate idea of their extreme tenuity. One is reminded of recent spectroscopic drawings of filamentary structures in the chromosphere (*Comptes Rendus*, vol. lxxvi, p. 1054), though here the appearance is more tree-like.

The course of this examination has, it is hoped, made it plain, that if the photosphere were really composed of spindle-shaped bodies about one hundred miles wide by one thousand long (nearly 0″·2 by 2″,—the dimensions of Mr. Nasmyth's "willow-leaves"), they would not have escaped notice. Yet while, with a confidence justified by the micrometric measurements of so much smaller bodies, we may say that Mr. Nasmyth was misled in a matter of detail, we should remember that he appears to have been the first to distinctly call attention to the singular individuality of the minute components of the photosphere, and this seems in fairness to entitle him to the credit of an important discovery, with which his name should remain associated.

Solar cyclones, which, even without the aid of the spectroscope we see are incomparably more violent than our own tropical tornados, act on the filaments without destroying their identity. It is probable that both the filaments and the granules I have so minutely described, may hereafter be resolved into smaller components still, but their persistent individuality as a whole under such disturbance, impresses me as a most striking feature, and one for which, under similar circumstances we have no exact analogy in our own meteorology.*

Let us now consider the filaments as indices of the character of the gaseous circulation of the sun as we see it in the spots. We find about F_4 and G_3 two considerable masses of the pho-

* In the recent conclusions of Clerk Maxwell and others, as to the viscosity of gases under high temperature, and in what is known of the diffusion rates of gases and vapors, we have occasion for interesting suggestions as to the possible explanation of some of their peculiarities, the consideration of which, however, does not form a part of our present subject.

tosphere nearly severed from the main body by rifts which are spreading behind them, and which in the reality we should see progressively widening until these spaces were islanded, and merged in the penumbra. Immediately below them at H_3 commences a "bridge." It starts from the general level of the photosphere, which it apparently maintains throughout the entire length (of nearly 15,000 miles), as it is nearly equally brilliant everywhere. *The whole length is traversed by a fine line*, (this and the strange form of the extremity being sketched from one of two bridges in the great spot of September, 1870.) The theory of an eminent modern physicist, that sun-spots are solar clouds, and the bridges rifts in the cloud through which the photosphere is seen, would doubtless have been modified by an opportunity for personal observation of such details.

In this respect, these minutiæ are of interest, their study suggesting answers to many questions, and enabling us to decide in part as to opposed theories. Near I_3 the filaments are contorted and thrown over each other, a thing of ordinary occurrence. The row of brilliant dots immediately below this is an appearance which has not escaped Secchi, who has an illustration of it. Its physical interpretation has never, I think, been given; we obtain it in connection with the study of the filaments immediately below. The filaments in general wear the appearance of lying in sheets, or like feathers on a quill, but here the planes in which they lie are tilted vertically (by the action of an ascending current?) so as to expose the tips only which form the dots. Immediately below an instance is given of the effects of a current apparently setting upward and forming part of a whirlwind with an axis greatly inclined to the vertical, two successive laminæ of filaments being both curved and tilted. Following these filaments down to the umbra, we find them nearly uniformly curved, and just beyond them the umbra filled with brilliant points, on a ground less dark than the general shade. From this part of the spot (K_4 to J_6), every filament is copied, in exact collocution with its neighbors, from nature. We observe that their curvature increases rapidly toward their ends, and that those almost in contact may have their curves opposed. The physical explanation of this appears to involve the assumption of the presence of numerous small and independent whirlwinds; even right-handed and left-handed whirls being in juxtaposition. A strange kind of bar lay across the tips of the filaments here, in a position which could not have been anticipated. I have occasionally observed filaments stretching in masses over the umbra, which have a resemblance to reeds bending over a stream (I_6), some of them growing darker near the ends as if dipping their tips in its turbid fluid. A very peculiar form, and one difficult of explanation at first, is that which I can best compare to the trunk of a fallen tree covered with snow, entirely smooth and straight upon one side, and hung with icicles on the other (I_6 to I_8).

In the spot whence this was taken, the appearance was so strikingly suggestive of crystalline structure, that it was necessary to recall that each "crystal" was from one to two thousand miles in length, to dispel the illusion. It is probably due to a rift in the photosphere (however caused), the filaments on opposing edges being partly drawn out and partly dissipated.

The appearance of the part of the spot just over this is inadequately represented in the sketch, and it would in fact be hard to depict it. Pine boughs covered with hoar-frost and icicles would not unfairly imitate its effect, for the impression derived in the polarizing eye-piece from the pure whiteness and the crystal-like forms of such portions is associated rather with cold than heat.

The umbra of a spot, as seen with this eye-piece, is a complex structure. The tips of the filaments, though usually bright as if turned up by an ascending current around the edges, are sometimes darker toward their extremities, as in an instance already cited (J_6); sometimes a whole bank of filaments appears submerged (I_4). Occasionally the bridges rise from below the photosphere, growing progressively brighter toward the extremity, as in a remarkable instance given in the sketch. The awkward termination of the bridge, bearing a certain rude resemblance to the outline of a human leg and foot, presents itself so often that I am inclined to attribute it to a constant cause.

It is a common thing to see a large spot built up by the adhesion of numerous groups of smaller ones. The appearance of these under low powers, is that of wholly isolated spots in accidental juxtaposition. Under closer scrutiny, however, they are seen to have a physical connection, denoted by faint outlines of cloud-forms of the photosphere, which unite them, and which take on the appearance of irregular *lines of rupture*, if I may use such an expression. (Several of these are given in the sketch, uniting the two main divisions of the drawing.) These lines of rupture are not always easily seen. They follow the irregular outline of the photospheric cloud-masses which determine them; frequently there is a uniform deeper shade at one side than another (G_{12} to I_{12}), and occasionally we make out that their course is bordered by an approximately horizontal disposition of the filaments like that seen in the penumbra. These ordinarily here show traces of cyclonic action. Incipient penumbræ they are, in fact, and the better our definition the more clearly we see, that not only this, but every part of the photosphere, repeats with modifications the behavior of the larger penumbræ, so that we may almost say the sun at times seems to be *all spot.*

In the spot of March 5th, and in the portion indicated in the sketch, a long filament was seen bent into a curious ear-shaped curve. Before a rough sketch of it was completed, the whole of the northwestern part of the curve disappeared, being drawn away from the rest and dissolving as it moved, passing from white through shades of reddish brown till it was lost in the tints of the umbra. The portion which suffered this remarkable dissolution was about 3,000 miles in length. Clear evidence of superposed currents is seen where one stratum of filaments drifts over another in a different direction (H_4, I_{14} and elsewhere). This phenomenon has been apparently observed by Lockyer* and Secchi† in isolated cases. It seems to me clearly discernible almost everywhere, and that it is the indication of an important physical law of the gaseous circulation of the sun. We must infer from it that the circulation is not wholly in ascending and descending currents, or from uniform cyclonic action, but that currents greatly inclined to the vertical, and often approximately horizontal, are also everywhere superposed in the penumbræ; of which the photospheric clouds give ocular evidence of the same kind, and nearly the same conclusiveness that assures us of the different currents superposed in the terrestrial atmosphere.

In the northern portion of the same spot, which was the center of violent disturbance, several remarkable forms presented themselves, for the study of which I had the good fortune of excellent definition. The most prominent bore a resemblance in outline to a plume, but had something in its structure, I do not know how to render exactly, or to describe. The appearance of a window-pane covered with frost-figures would give a not inadequate idea of its effect, which was at once foliate and crystalline; but in the original this effect was also that of such a figure viewed through successive veils of lace, each superposing a semi-transparent and fern-like pattern. The whole appearance was one of singular beauty, and the sketch gives a most inadequate idea of it.

I use the terms "foliate" and "crystalline" as accurately descriptive of the appearance merely, without intending to apply them to the organic cause of the structure. Since writing this, I notice that the same dual comparison has presented itself to Secchi, who likens an appearance, which presented itself at the extremity of a "bridge," at once to that of a cactus and that of a crystallization of sal-ammoniac. (See Secchi–

* Monthly Notices Roy. Ast. Soc., 1865. † Die Sonne, vol. i, p. 86.

Schellen, Die Sonne, vol. i, p. 78.) Considering that this remarkable object covered a greater area than the united North and South American continents, it seems probable that the "crystalline" appearance was due, in part at least, to the superposition of the filaments in numerous semi-transparent cloud strata, and the lace-like veils to nearly transparent strata suspended still higher. "Clouds" is the only word we can employ, since we can only illustrate by terrestrial analysis, but the structure of the terrestrial cloud is formless and indefinite by comparison. The higher the telescopic power we can apply to such solar clouds, the more definite becomes the structure: we find everywhere those strange objects we call granules, or filaments, or crystals,* taking more varied and more definitely foliate forms the more we analyze them. I might borrow here from Mr. Lockyer his comparison of certain chromospheric forms to an English hedge-row. Some of the appearances of the chromosphere and photosphere seem almost identical: perhaps in looking through the former we receive at times a confused impression of its existence even without the spectroscope.

A reference to the drawing will show a curious structure, which was sketched at the same time. Lying upon the opposite side of the umbra were four long filaments, or fascicles of filaments, of immense size, bent into curves which, as they are typical ones, should be studied in their physical connection. I refer particularly to the "quickening" of the curves near their extremity, or, in other words, to the progressive rate of diminution of the radius of curvature throughout their entire length, as a probable index of the distance from the axis to the circumference of the cyclone which produced them. Connecting these curves with the opposite penumbra were several others, which joined them in the peculiar way shown (C_{15} to C_{16}). These three were in the position of ropes made fast at both ends. [Notice the slight curve in each, the clear line on the concave, and the fringe on the convex side of the curve, as if it were blown out by the wind of the upper branch of the whirl.] Near the northwestern limits of the curve was a scene of violent disturbance. Even in the chaotic confusion here, it was noticeable that the filaments retained their individuality; far from blending into a common mist, they appeared here in short straight pieces as if broken. I say "as if," not meaning to predicate brittleness of their qualities, but at the same time asking attention to the appearance of these objects under such conditions, as one for which we could expect to find no good analogy in terrestrial clouds. Evidence of what appeared to be the meeting of right and left-handed whirls was not wanting in this part of the spot.

* A term already used by Chacornac.

It is very desirable to determine whether the penumbral slope is formed by a superior (or lateral) pressure which separates the photosphere, or whether it is built up by the deposits of vapors ascending from the sides of the umbra. I have made (B_{15}, B_{17}) a careful transcript from nature of every granule or filament visible in the penumbral edge for this distance. To me it seems that the edge of a torn piece of cloth, with its projecting threads, would not give clearer evidence of rupture.

I cannot conclude this description without speaking of the umbræ, though their study would form a chapter by itself. The polarizing eye-piece gives us interesting information about the nuclei or those darkish shades of the umbra discovered by Dawes.

Are these round, nearly central openings, so that looking into one we are looking into the axis of the cyclone to which the spot is due,—into the vortex of the great whirl *down* which the chromospheric vapors are being sucked by mechanical action? Are they ragged apertures—the craters as it were of eruptions whence metallic vapors are being forced *up?* The answer to this question, were there but these two alternatives, would be definitive as to our choice between the principal theories of solar circulation. But we cannot answer peremptorily in favor of either. I have seen these nuclei neatly defined, circular central apertures, but I have also and not unfrequently seen them ragged rents, as shown in the drawing. It is noticeable that the very darkest nuclei are sometimes close under the bright ends of filaments, which it would seem could not present their usual aspect with the downward suction of a cyclone beneath them.

I will briefly recapitulate those of the results of these telescopic studies which seem to have been before little observed or undescribed.

The ultimate visible constituents of the solar photosphere being, not the rice-grains, but smaller bodies which compose them, and the size of these latter being valuable at not over 0″·3; from a comparison of the total area covered by them with that of the whole sun, we are entitled to say that the greater part of the solar light comes from an area of not over one-fifth of its visible surface, and which may be indefinitely less.

We must then greatly increase our received estimates of the intensity of the action to which solar light (and presumptively its heat and actinism) are due, on whatever theory we form them. (There is a presumption from observation that there is a drift of all the photosphere in a direction approximately parallel to its equator, while the evidence as to this point is not yet conclusive.)

In the penumbræ there are not only numerous small cyclones, and even right and left-handed whirls in the same spot, but probably currents ascending nearly vertically, while the action of superposed approximately horizontal currents is so general that they must be considered a prominent feature in our study of solar meteorology.

A study of the outer penumbral edge leads to the conclusion that it is formed by rupture.

Speaking without reference to spectroscopic investigations, it seems to me that we have in the behavior of our filaments a presumption as to the existence of ascending currents in the outer penumbra, and of both ascending and descending currents at the umbral edge; ascending ones being the more usual. I think I recognize with this, and very commonly, currents setting inward and upward from the outer confines of the spot, and I find no difficulty in associating the idea of these phenomena with that of cyclonic action. Let us remember that though the spot shown in our drawing is by no means one of the largest, the umbra of its left branch alone covers an area of over 100,000,000 English miles. If we keep the real vastness of the field of these operations before our minds, and use the terms in not too absolute a sense, we shall be able to see the truth of both the eruptive and cyclonic theories, in the coexistence of phenomena, which, discussed separately, would justify either.

It seems, however, hardly possible to devote long telescopic observation to the minute structure of the photosphere, without reaching the conclusion, that evidence of the cyclonic action is the more widely marked, and—while recognizing that the normal type of the cyclone-spot is rare, that the evidence of cyclonic action away from the spots is feeble, and that in them such action apparently does not explain all these phenomena—we yet cannot withhold a more or less complete acceptance of the theory of Faye, as one unquestionably resting upon a *vera causa*, and uniting beyond any other, a wide range of otherwise isolated truths under a single law.

Allegheny Observatory, Dec., 1873.

ART. XIV.—*Measurements of the Polarization of the Light reflected by the Sky, and by one or more plates of glass;* by Prof. EDWARD C. PICKERING.

THE following observations, which will be published in full in the Proceedings of the American Academy of Arts and Sciences, were conducted to test Fresnel's formula for the reflection of light. He showed that if the light was polarized in the plane of incidence, the amount reflected would be $A=\frac{\sin^2(i-r)}{\sin^2(i+r)}$, while, if polarized in a plane perpendicular to it, the proportion would be $B=\frac{\text{tang}^2(i-r)}{\text{tang}^2(i+r)}$, i and r representing the angles of incidence and refraction respectively. Natural light may be regarded as composed of two equal beams polarized at right angles, hence the amount reflected $R=\frac{1}{2}(A+B)=\frac{1}{2}\left(\frac{\sin^2(i-r)}{\sin^2(i+r)}+\frac{\text{tang}^2(i-r)}{\text{tang}^2(i+r)}\right)$, a formula which may be applied to any special case, by substituting proper values for i and r. The value of A evidently increases as i varies from 0° to 90°. That of B, on the other hand, diminishes from 0° until $i+r=90°$, when it equals 0, or at this angle, which is that of total polarization, all of the ray B is transmitted, all the reflected beam being polarized in the plane of incidence. When $i=90°$, $A=1$, $B=1$, hence all the light is reflected. When $i=0°$, A, B, and R equal $\left(\frac{n-1}{n+1}\right)^2$, hence the reflected light increases with n, being zero when $n=1$, and 100 per cent when $n=\infty$. Many familiar phenomena are thus readily accounted for. For instance, the brightness of the diamond, the covering power of white lead as a paint, and the brilliancy of wet or varnished stones and woods.

A curious case presents itself when $n=1+dn$ or differs from unity only by an infinitesimal amount. A then becomes equal to $\frac{1}{4}dn^2\ (1+\text{tang}^2 i)^2$, and $B=\frac{1}{4}dn^2\ (1-\text{tang}^2 i)^2$. When $i=0°$, A, B, and R equal $\frac{1}{4}dn^2$, and this quantity is accordingly taken as the unit in Table I. The first column gives various values of the angle of incidence, the second and third the corresponding values of A and B, the fourth the amount of light reflected, and the fifth the degree of polarization. The other columns will be explained hereafter. This table is evidently applicable to all cases where the media bounding the surface have nearly the same index, whether its absolute amount is great or small.

TABLE I.—Light reflected when n is near unity, or equals $1+dn$.

i	A	B	$\frac{1}{2}(A+B)$	$\frac{A-B}{A+B}$	Theor.	Obs.	Differ.
0°	1·000	1·000	1·000	0·0	0·0	0·0	0·0
5	1·015	·985	1·000	1·5	1·0	1·0	0·0
10	1·063	·939	1·001	6·2	4·2	3·5	+0·7
15	1·149	·862	1·005	14·3	10·0	9·0	+1·0
20	1·282	·752	1·017	26·0	18·2	17·5	+0·7
25	1·482	·612	1·047	41·5	29·0	28·5	+0·5
30	1·778	·444	1·111	60·0	42·0	41·0	+1·0
35	2·221	·260	1·240	79·1	55·4	56·0	—0·6
40	2·904	·088	1·496	94·5	66·1	67·0	—0·9
45	4·000	·000	2·000	100·0	70·0	72·0	—2·0
50	5·857	·176	3·016	94·5	66·1	68·0	—1·9
55	9·239	1·081	5·160	79·1	55·4	58·0	—2·6
60	16·000	4·000	10·000	60·0	42·0	44·0	—2·0
65	31·346	12·952	22·149	41·5	29·0	30·0	—1·0
70	73·079	42·884	57·981	26·0	18·2	18·0	+0·2
75	222·85	167·16	195·00	14·3	10·0	8·5	+1·5
80	1099·85	971·21	1035·53	6·2	4·2	3·0	+1·2
85	17330·64	16808·08	17069·36	1·5	1·0	1·0	0·0
90	∞	∞	∞	0·0	0·0	0·0	0·0

The most important application of Fresnel's formula is to the case of glass where n somewhat exceeds 1·5. The first portion of Table II. gives in an abreviated form the result of a computation, for various values of i, of A, B, R and the polarization of the reflected and refracted rays. When, as frequently happens in the case of plates of glass, the light passes through several parallel surfaces, a portion of the light reflected back by the second surface is again intercepted by the first surface. It may readily be proved that if A is the amount reflected by a single surface, the amount transmitted, including this internal reflection, will be $\frac{1-A}{1+(m-1)A}$, while if no internal reflection took place it would be only $(1-A)^m$. In Table II. the values of A, B, R and of the polarization, are given for 2, 8, and 20 surfaces, corresponding to 1, 4, and 10 plates of glass. In all these cases the index $n=1·55$.

These results are perhaps better shown in figs. 1 and 2, in which abscissas represent values of i, and ordinates percentages of polarization.

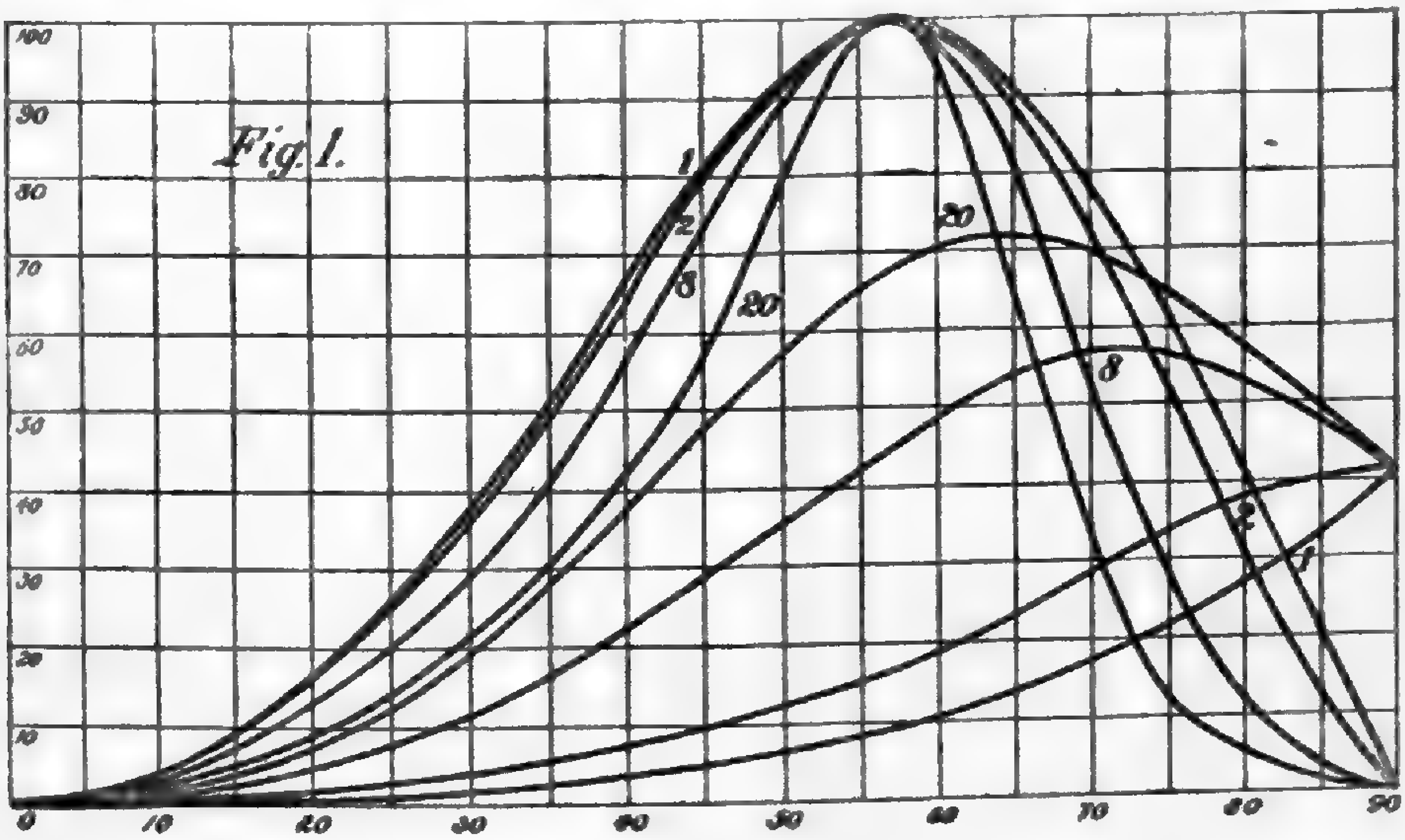
In fig. 1, the four highest curves represent the polarization of the beams reflected by 1, 2, 8, and 20 surfaces. The other four curves give the corresponding refracted beams. Fig. 2 gives all the curves of Table II, relating to twenty surfaces; the five curves corresponding to A, B, the intensity of the refracted beam, and the polarization of both the reflected and refracted beams. When $i=0$, both the reflected and refracted beams are unpolarized. With ten plates of glass about half the

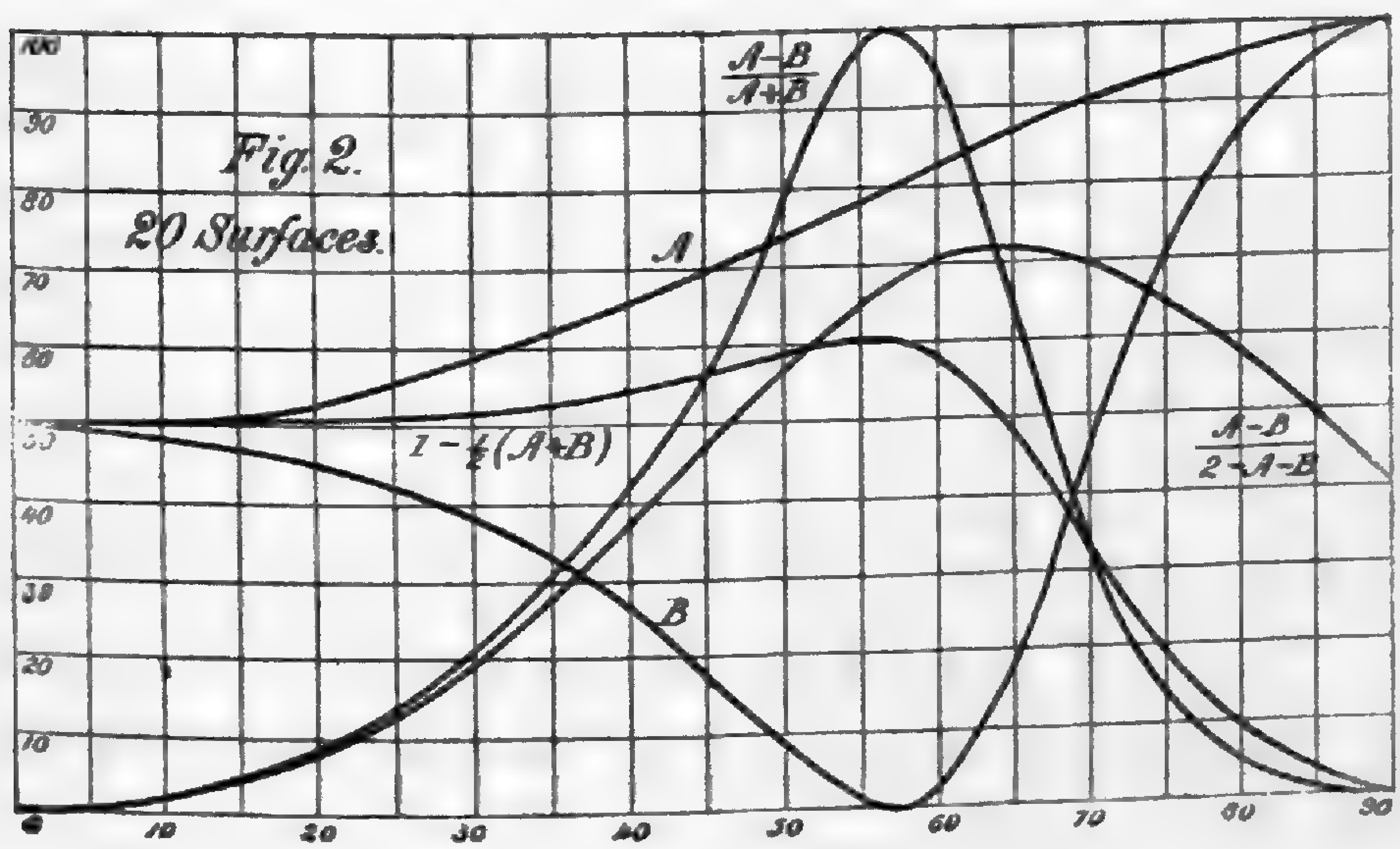
TABLE II.—*Light reflected by* 1, 2, 8, *and* 20 *Surfaces.*

	1 Surface.					2 Surfaces, 1 Plate.				
				Per ct. Polariz.					Per ct. Polariz.	
i	*A*	*B*	Reflect.	Reflect.	Refract.	*A*	*B*	Reflect.	Reflect.	Refract.
0°	4·6	4·6	4·6	0·0	0·0	8·8	8·8	8·8	0·0	0·0
5	4·7	4·6	4·6	1·0	0·0	9·0	8·7	8·8	1·0	0·1
10	4·8	4·5	4·7	4·0	0·2	9·2	8·6	8·9	4·1	0·4
15	5·1	4·2	4·7	9·1	0·4	9·8	8·1	8·9	9·2	0·9
20	5·4	3·9	4·7	16·4	0·8	10·4	7·5	8·9	16·3	1·6
25	5·9	3·5	4·7	25·9	1·3	11·1	6·7	8·9	25·4	2·5
30	6·6	3·0	4·8	37·8	1·9	12·5	5·8	9·1	36·4	3·6
35	7·5	2·4	5·0	51·7	2·7	14·2	4·7	9·4	49·3	5·2
40	8·8	1·7	5·3	66·7	3·7	16·4	3·5	10·0	64·0	7·2
45	10·4	1·1	5·7	81·2	4·9	19·0	2·1	10·6	80·1	9·4
50	12·5	0·5	6·5	92·9	6·5	22·4	0·5	11·4	95·6	12·5
55	15·4	0·1	7·7	99·3	8·3	26·9	0·1	14·0	99·3	15·6
57	17·0	0·0	8·5	100·0	9·3	29·1	0·0	14·5	100·0	17·0
60	19·3	0·1	9·7	98·8	10·6	32·4	0·2	16·3	98·8	19·2
65	24·7	1·1	12·9	91·2	13·5	38·4	2·5	20·4	87·7	23·2
70	32·0	4·0	18·0	77·7	17·1	48·5	7·7	28·1	72·6	28·4
75	42·0	10·4	26·2	61·8	21·9	59·6	19·7	39·1	52·2	33·2
80	55·7	23·3	39·5	41·0	26·8	71·7	38·0	54·8	30·7	37·2
82	62·6	31·6	47·1	32·8	29·3	77·1	48·3	62·7	22·7	38·6
84	70·3	42·4	56·3	24·7	32·1	82·7	60·2	71·4	15·7	39·6
85	74·5	49·0	61·8	20·6	33·3	85·4	68·5	75·8	12·6	40·0
86	79·0	56·6	67·2	16·5	34·8	88·2	72·5	80·3	9·8	40·4
87	83·8	65·3	74·6	12·4	36·3	91·4	79·2	85·3	7·0	40·8
88	88·9	75·3	82·1	8·2	37·9	94·1	86·1	90·1	4·4	41·0
89	94·3	86·8	90·5	4·1	39·6	96·9	92·9	94·9	2·0	41·1
90	100·0	100·0	100·0	0·0	41·2	100·0	100·0	100·0	0·0	41·2

	8 Surfaces, 4 Plates.					20 Surfaces, 10 Plates.				
0°	28·3	28·3	28·3	0·0	0·0	49·4	49·4	49·4	0·0	0·0
5	28·6	28·0	28·3	0·9	0·3	49·7	49·1	49·4	0·6	0·6
10	29·2	27·4	28·3	3·4	1·2	50·4	48·3	49·3	2·1	2·1
15	30·2	26·3	28·3	7·4	2·7	51·5	46·9	4[illegible]·2	4·7	4·6
20	31·9	24·5	28·2	13·1	5·1	53·3	44·9	49·1	8·5	8·3
25	33·9	22·4	28·2	20·3	7·9	55·8	42·2	49·0	13·9	13·4
30	36·3	19·8	28·1	29·2	11·4	58·7	38·2	48·4	21·2	19·7
35	39·5	16·5	28·0	41·1	16·0	62·2	33·0	47·6	30·9	27·9
40	43·7	12.1	27·9	56·4	21·8	65·9	26·3	46·2	42·4	36·7
45	48·3	7·4	27·9	73·3	28·1	69·8	17·1	43·4	55·9	46·6
50	53·5	3·2	28·3	88·7	35·1	74·1	8·5	41·3	79·5	56·4
55	59·4	0·5	30·0	98·3	42·0	78·4	1·0	39·7	97·5	64·5
57	62·1	0·0	31·0	100·0	45·0	80·4	0·0	40·2	100·0	67·2
60	66·3	1·7	34·0	95·0	48·9	82·8	2·4	43·6	94·5	71·0
65	72·5	7·6	40·0	81·0	54·1	86·9	18·6	52·7	64·7	72·2
70	79·0	25·0	52·0	51·9	56·3	90·4	45·5	68·0	33·0	70·0
75	85·3	48·2	66·7	27·8	55·8	93·5	69·9	81·7	11·3	64·6
80	91·0	71·1	81·0	12·3	52·6	96·2	85·9	91·0	5 6	57·1
82	93·1	79·0	86·0	8·2	50·5	97·1	90·3	93·7	3·6	54·0
84	95·0	85·5	90·2	5·2	48·6	97·9	93·7	95·8	2·2	50·9
85	95·5	88·4	92·0	3·8	47·5	98·3	95·1	96·7	1·6	49·3
86	96·8	91·3	94·0	2·6	46·2	98·7	96·4	97·5	1·2	47·7
87	97·6	93·8	95·7	1·7	45·0	99·0	97·4	98·2	0·8	46·1
88	98·4	96·1	97·2	1·1	43·8	99·4	98·4	98·9	0·5	44·5
89	99·2	98·1	98·6	0·5	42·5	99·7	99·2	99·4	0·2	42·9
90	100·0	100.0	100·0	0·0	41·2	100·0	100·0	100·0	0·0	41·2

light is reflected, the transmitted ray being but little brighter than that reflected. With 1 or 2 surfaces the reflected beam





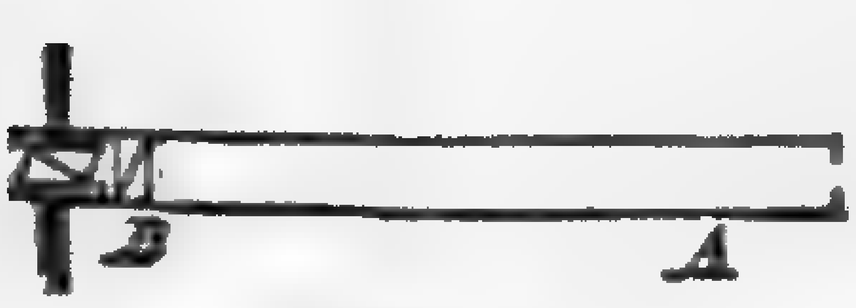


Fig. 3.

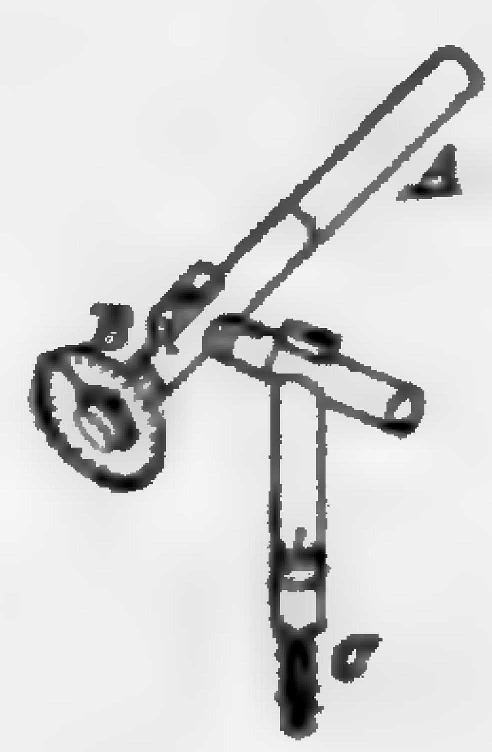


Fig. 4.

increases as i increases; with 8 surfaces it remains nearly constant up to 50°; while with 20 surfaces a marked diminution is perceived. This very remarkable result may be expressed by saying that ten plates of glass transmit more light obliquely than normally. The appearance to the eye confirms this result, but it deserves a careful photometric proof. At 57° the reflected ray is, of course, in all cases, totally polarized; but at other angles the amount of polarization is greater the less the number of surfaces, instead of the contrary, as might have been anticipated.

With the refracted ray quite a different law holds. For one surface the polarization increases from 0° to 90°; with two surfaces it becomes sensibly constant near 90°; while with a larger number a distinct maximum is obtained. It is commonly supposed that the greatest effect is obtained at the angle of total polarization. But the maximum is sensibly beyond this, unless a very large number of plates is employed; and hence it seems probable that a bundle of plates, polarizing by refraction, would give the best results if set at a greater angle than 57°, as 65° or 70°. The transmitted ray, however, diminishes rapidly for large angles of incidence. A very large number of plates is required to render the polarization nearly complete, which accounts for the light always remaining when even the best polariscopes by refraction are crossed. At 90° all the refracted beams are polarized by the same amount of 41·2 per cent. Or, at grazing incidence, the amount of polarization is independent of the number of plates, one polarizing as completely as a hundred. This number 41·2 may be obtained as follows. Differentiate the value of A in terms of i and r, and make $i=90°$, when the refracted beam will equal $1-A=4 \tan r\, di=3{\cdot}376\, di$, since when $i=90°$, $r=40°\ 10'{\cdot}7$. In the same way $1-B=\frac{8}{\sin 2r}\, di=8{\cdot}115\, di$, and applying to them the formulæ for the polarization of the refracted beam, we find it equal to 41·2.

To show how far these effects are due to internal reflection, another table was computed by the formula $(1-a)^m$, or supposing that no internal reflection took place. A comparison showed that while the reflected beam is affected but little a great change takes place in the transmitted light. The results are shown by dotted lines in figs. 7, 8, and 10, and will be discussed below.

To test the above conclusions, two experimental methods may be employed. First, by means of a photometer, to determine the amount of light in any given case; and, secondly, by means of a polarimeter, to determine the percentage of polarization of the reflected and refracted rays. The latter method has been employed in the following experiments. The instrument commonly used to measure the amount of polarization was invented by Arago, and is called a polarimeter. It consists of a Nicol's prism and Savart's plates, in front of which are several glass plates, free to turn, and carrying an index which moves over a graduated circle, thus showing the angle through which they have been rotated. The prism and plates form a Savart's polariscope, which gives colored bands with either light or dark center, according as the plane of the prism is parallel or perpendicular to the plane of polarization. When the plates are so placed that the light passes through them normally, they have no effect on it; but when turned, they polarize it in a plane parallel to the axis of rotation, and by an amount dependent on the angle. Let the instrument be so set that the axis of rotation shall be perpendicular to the plane of polarization, and the plates set at zero. The bands will then be visible, the center one being bright. As the plates are turned, the bands become fainter, until their polarization neutralizes that originally present in the beam; beyond this point the bands reappear dark-centered. The amount of polarization is thus readily determined, by turning the plates until the bands disappear, when the angle is reduced to percentages by means of a table. The difficulty of computing this table is, however, the real objection to the use of this instrument. It may be determined by the formulæ given in the first part of this paper, but it of course then fails to prove them. Moreover, no account is taken of imperfect transparency, dust on the surface, and other sources of error. An excellent way of forming this table experimentally is to view through the instrument a beam of light totally polarized. If now the plane of polarization of the beam is changed, the percentage of polarization will alter, being zero when it is inclined 45° to the axis of the plates, and wholly polarized at an angle of 0° or 90°. At any angle a, the beam may be regarded as composed of two, $\cos^2 a$ polarized vertically, $\sin^2 a$ polarized horizontally. The percentage of polarization will therefore equal $\frac{\cos^2 a - \sin^2 a}{\cos^2 a + \sin^2 a} = \cos 2a$, from which the polarization corresponding to any given angle is readily determined.

The result of such a comparison is given in Table III. Four series of observations were taken, from which curves were constructed as in fig. 8, with angles of incidence as abscissas and percentages of polarization as ordinates. A curve was next drawn, coinciding with them as nearly as possible, and its ordinates are given in Table III, column 3; the angles of incidence are given in the first column, and the theoretical polarization in the second column of the same table. Column 4 gives the differences, and from it we see that, while the agreement is very close between 0° and 60°, above this point a marked variation is perceptible. This deviation will be further discussed in connection with fig. 8.

TABLE III.—*Table for Arago's Polarimeter.*

i	Theoretical.	Empirical.	Difference.
0°	0·0	0·0	0.0
20	5·1	5·0	−0.1
30	11·4	13.0	+1·6
40	21·8	23.5	1·7
50	35·1	37.0	1·9
55	42·0	43.0	1·0
60	48·9	49.0	0·1
65	54.1	57.5	3·4
70	56.3	63.5	7·2
75	55.8	67.0	11·2
80	52.6	72.0	19·4

To avoid the defects of the above instrument, the following arrangement has been employed. A brass tube, *A B*, fig. 3, about a foot long, is closed at one end by a double image prism, *B*, and at the other by a rectangular aperture, *A*, of such a width that its two images, as in the Arago polariscope, shall be in contact, but not overlapping. To the prism is attached a Nicol's prism, free to turn, and carrying an index, moving over a graduated circle, which shows how far it has been rotated. The tube is then mounted, so that it can be set at any altitude or azimuth, or rotated around its own axis, and three graduated circles serve to measure these quantities. In the instrument as actually constructed (fig. 4), the whole is supported on an upright, which terminates below in a large screw, *C*, by which it may be attached to a post or tree, when used out of doors. A tube slips over this, which carries a cross-piece forming a **T**, and through the top of this passes the end of a second **T**, through the end of which the polarimeter slides. Three of these tubes are graduated to show the azimuth and altitude of the polarimeter tube, and the amount it is turned around its own axis.

The working of the instrument is as follows. If the Nicol's prism is removed, and the light is unpolarized, the two images of the aperture at the end will be equally brilliant. If now the Nicol's prism is replaced and turned, the images will vary in brightness, alternately disappearing as intervals of 90°. If the light is polarized, one image will in general be brighter than the other; but by turning the Nicol's prism, certain positions will always be found in which the two images will be equal. The percentage of polarization is then readily determined from the angle through which the prism has been turned. To determine the law which connects these two, let the plane of polarization be vertical, and the line of junction of the two images parallel to it. Then call *A* and *B* the brightness of the two images respectively, in which case the polarization $p = \frac{A-B}{A+B}$. If the prism is turned through an angle v, one image will have a brightness $A \sin^2 v$, the other $B \cos^2 v$; and if they are equal, $A \sin^2 v = B \cos^2 v$, hence $p = \frac{\cos^2 v - \sin^2 v}{\cos^2 v + \sin^2 v} = \cos 2v$. The amount of polarization is then very simply found by turning the Nicol until the images are equal, then reading the angle, doubling it, and taking the cosine. Evidently there are four positions of equality of the image; and in the following experiments all four were observed, reading to tenths of a degree, and the mean taken. The results may be reduced by a table of natural cosines, first multiplying the angle by two. Evidently when the light is unpolarized the angle will be 45°; when totally polarized 0°. When the line of junction is inclined to the plane of polarization by an angle w, the observed polarization $p' = p \cos 2w$. This suggests a means of determining the direction of the plane of polarization. Make two observations of the amount of polarization, turning the polarimeter 45°. Then call p, p', p'', the true and the observed polarization in the two cases, and w the unknown angle between the line of junction in its first position and the plane of polarization. Having given p' and p'', we wish to determine p and w. Evidently $p' = p \cos 2w$, and $p'' = p \cos 2(45° - w) = p \sin 2w$. Taking their quotient gives $\text{tang } 2w = \frac{p'}{p''}$, and the sum of their squares gives $p = \sqrt{p'^2 + p''^2}$. This method, though elegant theoretically, does not appear very accurate practically, as the plane is more accurately determined by covering the end of the polarimeter with a cap containing a plate of selenite, thus converting it into an Arago's polariscope. Then turn the tube until the two images have precisely the same color, when their line of junction will be inclined 45° to the plane of polarization. The plane may also be determined, more easily but less accurately, by removing the Nicol's prism, turning the tube until the two images are equally bright, and adding 45° to the reading.

We next wish to determine the delicacy of this instrument in different parts of its scale. If the Nicol's prism is set at an angle v', differing slightly from its true value v, the brightness of the two images will be $A \sin^2 v'$ and $B \cos^2 v'$ respectively. Now it is commonly assumed that the difference in two such images will be perceptible, when the difference in brightness, divided by the brightness of either, equals a certain fraction $\frac{1}{a}$, in which a equals about 80. By differentiation it may be proved that the error in p or dp corresponding to any value of a is given by the formula $dp = \frac{1-p^2}{2a}$, from which the error in the result for any unobserved difference in brightness of the two images is readily determined.

If $p=0$, $dp=\frac{1}{2a}$, its greatest value, which diminishes as the polarization increases, becoming zero when $p=0$. Hence the greater the polarization, the more accurately it can be measured. If $a=80$, $dp=\frac{1}{160}$ for its greatest value; hence the instrument should always give results within two-thirds of 1 per cent. Observation, however, shows that the error is much greater, a difference in brightness of $\frac{1}{80}$ being by no means perceptible.

The first series of observations were made on the light of the sky. The instrument was screwed into a post and levelled, the altitude and azimuth of the sun taken, and the instrument then directed toward the points to be observed. Most of these were in the same vertical plane with the sun, so that it was only necessary to determine their altitudes. The line of junction was then brought parallel to the plane of polarization; that is, turned until it was vertical, since it then lay in the plane passing through the sun. The four positions of the Nicol's prism, in which the two images were equally bright, were then observed, reading the angles to tenths of a degree, and taking the mean. The percentage of polarization was finally obtained as described above. Eleven series of observations were taken, nine at Waterville, N. H., in a valley at a height of 1500 feet, surrounded by mountains 4000 feet high; the other two from the top of the Institute of Technology, Boston. It soon became evident that the polarization depended on the solar distance of the point under observation, and not on the altitude. This is well shown in fig. 5, in which abscissas give the solar distances, and ordinates the polarization of the observed points. The sun's altitude varied in these series from 0° to 68°.

Before discussing these observations further, it seemed desirable to determine the polarization of other parts of the atmosphere not lying in the same vertical plane with the sun. Moreover, as the polarization of points at equal distances from the sun should be compared, the polarimeter was so mounted that its principal axis would pass through the sun. The two graduated circles would then give solar distances, and the angle from the vertical plane through the sun, instead of altitudes and azimuths. The second of these angles will be called the meridian distance, and will be regarded as positive to the right, and negative to the left of the sun. Of course, the direction of the axis should continually change, so as to follow the sun; but as great accuracy in the determination of the angles was not needed, it was found sufficient to re-adjust it every few minutes. Another advantage of this arrangement was, that the line of junction, being turned parallel to the axis, would always lie in

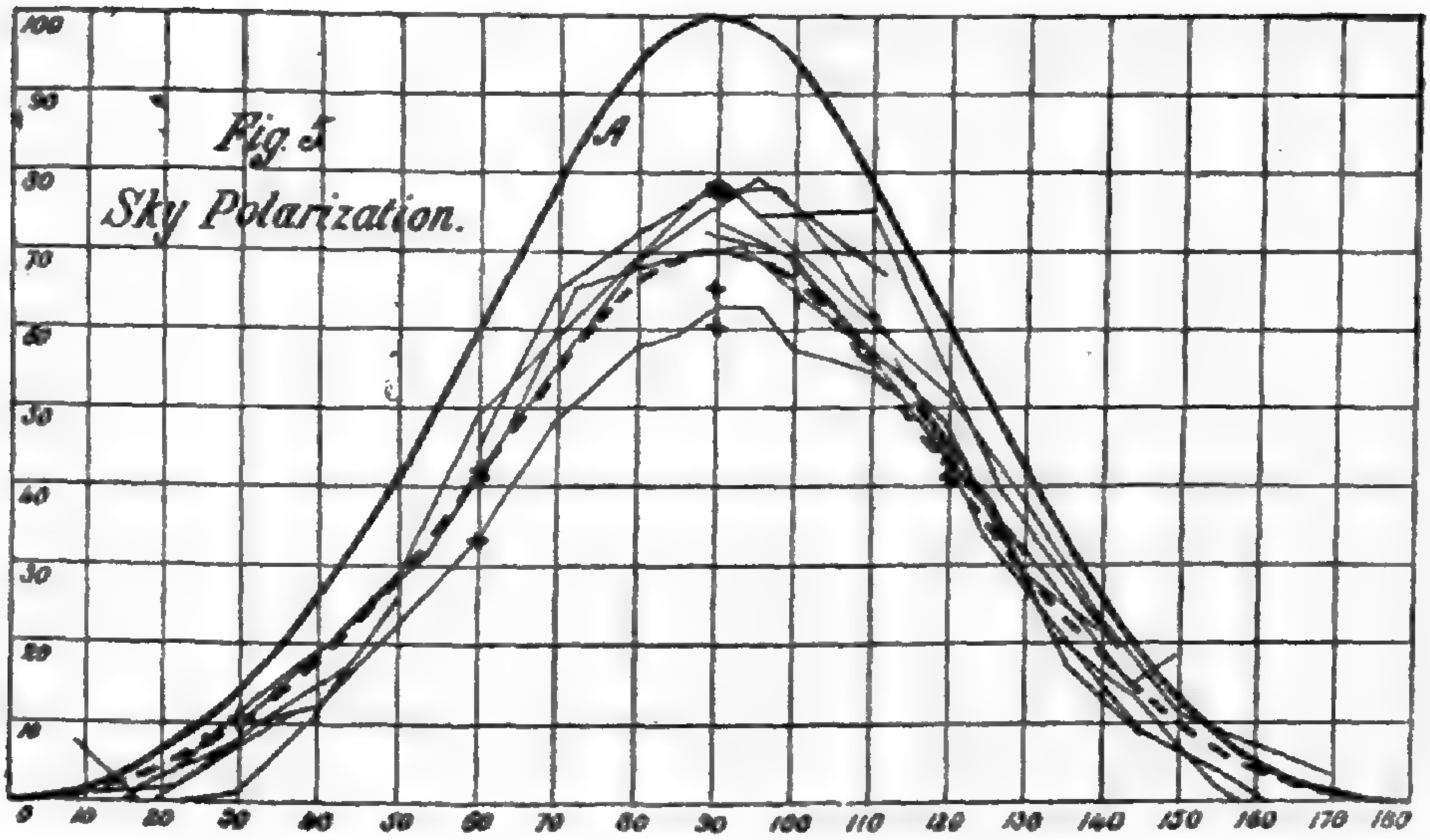


Fig. 5
Sky Polarization.
A

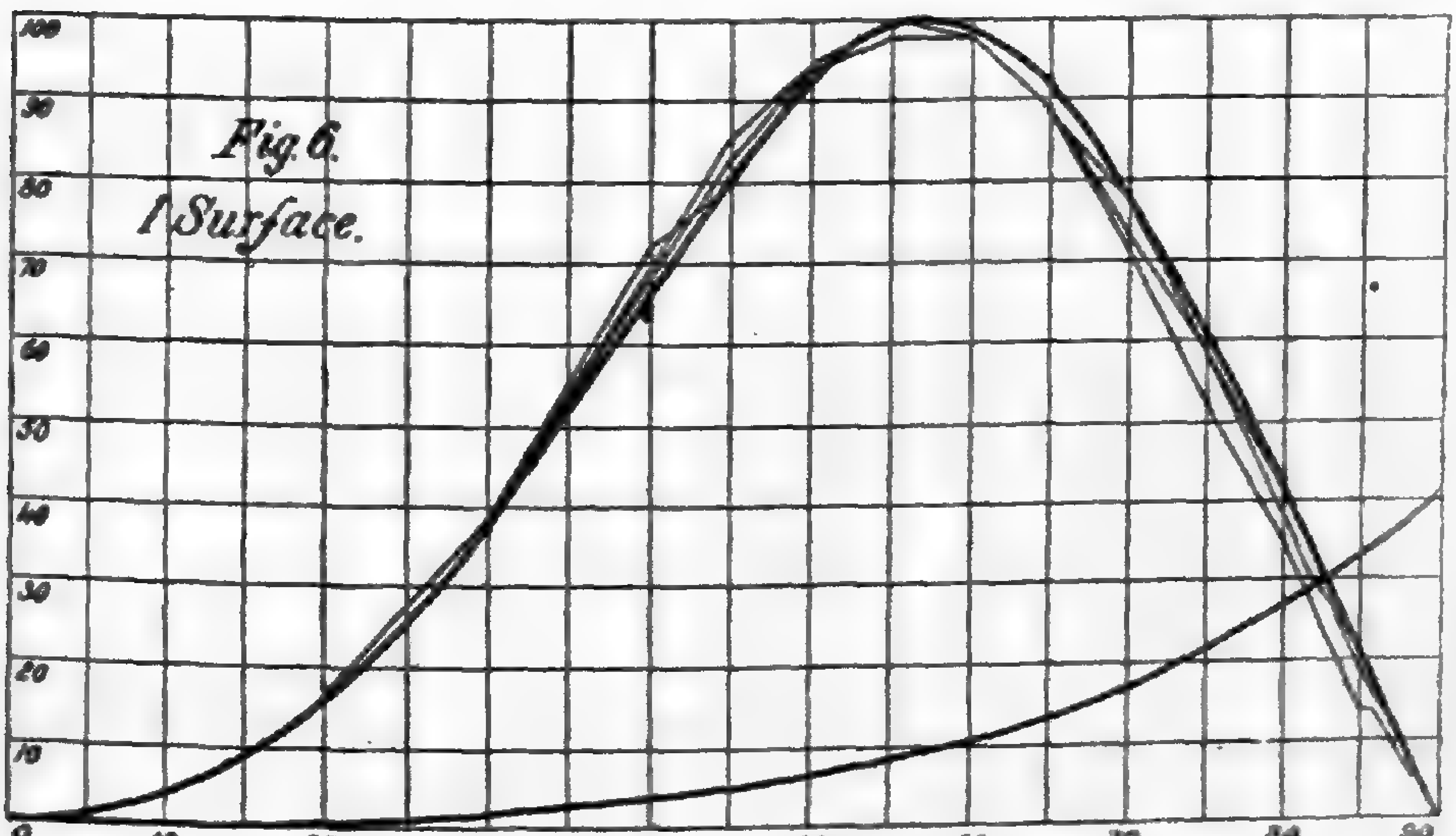


Fig. 6.
1 Surface.

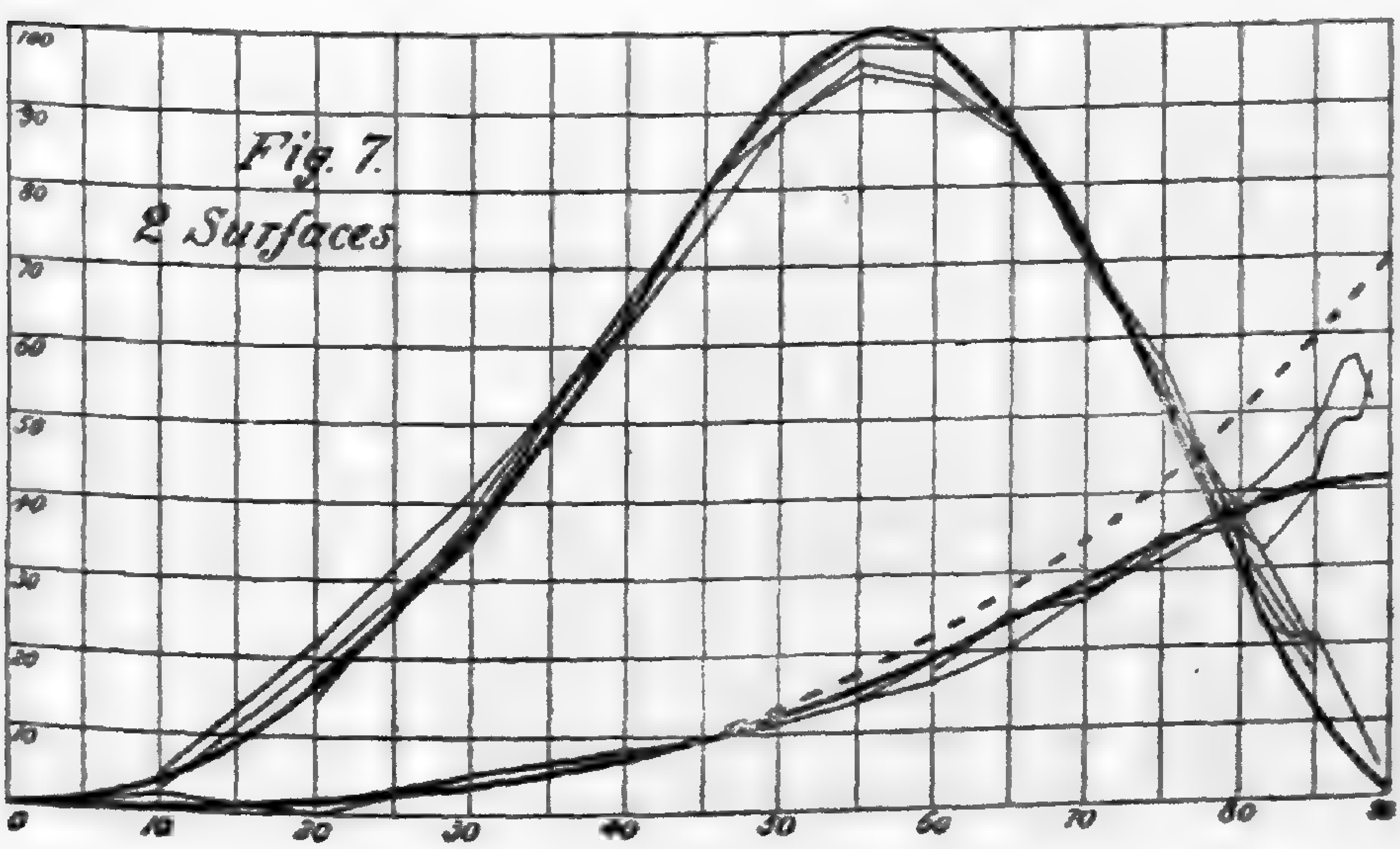


Fig. 7.
2 Surfaces.

the plane passing through the sun, and hence be parallel to the plane of polarization. Five series of observations were made in this way, all tending to show that the polarization was independent of the distance of the point to the right or left of the plane passing through the sun. The results are given in Table IV, in which the first column gives the number of the series, the second the sun's altitude, the third its distance from the points observed, the fourth the number of the latter, and the fifth their mean polarization.

TABLE IV.—*Polarization of points equidistant from the sun.*

Series.	Alt.	Dist.	Theo.	Pol'n.
12	5°	90°	9	76·7
13	20°	60°	6	42·9
14	48°	90°	8	65·4
	45°	60°	10	41·7
	42°	120°	2	42·4
	40°	30°	8	10·7
15	40°	90°	10	60·4
	41°	120°	9	40·9
	43°	60°	10	34·2
16	−5°	90°	6	77·5

One series, the first, is given in full in Table V, to show the amount of variation of the different points observed.

TABLE V.—Series 12. July 15.
Sun's Distance 90°, Altitude 5°.

M. D.	Polar.
75	78·6
60	74·3
45	79·8
30	77·0
0	77·2
30	74·8
45	75·2
60	76·8
75	76·8
Mean	76·7

All these observations point to one very remarkable result; namely, that the polarization is the same for a given solar distance for any meridian distance; in other words, that the polarization is the same for all points equally distant from the sun. The variations in the observations are to be ascribed partly to errors of observation and partly to real irregularities in the atmosphere, as it is evident that they follow no regular law. The means therefore give us the true polarization with much greater accuracy. They are represented in fig. 5 by small crosses. The next thing is to determine the law which connects the polarization with the solar distance in all these observations. A drawing was made like fig. 5 enlarged, and a fine copper wire laid on it, and bent into such a shape that it should coincide as nearly as possible with all the observations. The ordinates for every 10° were then read off, giving the results entered in column 7, headed Obs., of Table I.

A simple explanation of the polarization of the sky is to assume that it consists of molecules of air or aqueous vapor, which reflect the light specularly, and whose index of refraction differs only by a very minute amount from that of the medium in which they float. The theoretical polarization would then be at once given by Table I, making i equal to one-half the solar distance. The curve thus obtained is given in fig. 5, at *A*. The polarization according to this should be complete at 90° from the sun, while in reality it is only about 70 per cent. If, however, we multiply the ordinates of curve *A* by this fraction, we obtain curve *B*, which agrees almost precisely with the curve given in column 7 of Table I. Its ordinates are given in column 6, and the differences in column 8. From the latter it will be seen that the empirical curve gives results somewhat too great for solar distances less than 60°, and too small for greater distances; but the deviation is so small, compared with the accidental errors, that we are justified in regarding the agreement as complete within the limits of errors of observation. It will be noticed that no account is here taken of the points of no polarization, or neutral points of the sky; but the polarization is very slight for some distance from them, and hence is not easily measured. They must be regarded as due to some secondary disturbing cause, as refracted light, which alters the general polarization of the sky but little.

When the polarimeter is directed toward a polished colored plane surface, the two images assume different tints. One, which contains the light polarized in the plane of incidence, or *B*, is composed mainly of the light reflected specularly, and is therefore white like the source of light. The image *A* contains but little of the light reflected specularly, consisting principally of the rays emitted by the body, and hence partaking of its color. The idea at once suggested itself that testing the light of the sky in this way might give a clue to the cause of its color. The experiment was tried several times, with negative results, the two images appearing of precisely the same blue tint. But on the evening of July 15th, near sunset, when measuring the polarization of a point near the northern horizon, where the blue color was comparatively pale, a marked difference in the two images was observable. The image *B* was found to be of a yellowish brown, *A* of a grayish blue or violet tint. This observation has since been frequently repeated, and can, in fact, be made almost any clear evening near sunset.

Evidently we may conclude from these colors that the true color of the sky particles is blue, a view quite in accordance with the observations of Prof. Cooke with the spectroscope, and Prof. Tyndall on aqueous vapor in a state of formation.

Observations were next made to test the results formed above for the light reflected and transmitted by several parallel surfaces of glass. To check the results which are given in figs. 6–10, two, and in some cases three, independent methods were employed. To measure the polarization of the reflected ray, one or more sheets of glass were laid on a piece of black velvet and rendered horizontal with a spirit-level. The polarimeter was mounted a short distance from them, carefully levelled and turned down, so that the light should be reflected from their surfaces. Its angle of depression would then equal the complement of the angle of incidence. The line of junction of the two images was then rendered vertical, and the polarization measured in the usual way. The polarization of the sky, if clear, would introduce a large error into the results, and care was therefore taken to make these observations only on cloudy days. The second method was to replace the slit of a large Babinet's goniometer or optical circle by a Nicol's prism, which was free to turn around its axis, the angle of rotation being measured by a graduated circle and index. In the eye-piece of the observing telescope a Nicol's prism was placed, and in front of it quartz wedges giving lines, which were bright or dark-centered, according as the transmitted ray was polarized vertically or horizontally. On looking through the telescope, the field was seen to be traversed with lines, which disappeared only when the Nicol in the collimator was inclined 45° with the vertical. At any other angle, a, the vertical and horizontal components were $\cos^2 a$ and $\sin^2 a$, and hence were equivalent to a beam polarized vertically by an amount $\cos 2a$. If now any object was inserted between the two telescopes polarizing the light horizontally, p, the bands would disappear only when $p = \cos 2a$. Measuring the four positions of disappearance, and taking their mean, gave an accurate measure of the polarization by a table of natural cosines, as with the polarimeter described above. Another way of expressing the effect of this instrument is to say that the bands disappear when the Nicol is so turned that the plane of polarization shall be brought by the object under examination to an angle of 45°. The method of measuring the polarization of the reflected ray is now obvious. The pieces of glass are placed vertically on the center plate between the two telescopes, the latter set at an angle of $2i$, and the glass turned until the light is reflected from its surface, so as to render the field bright. The Nicol is then turned until the bands disappear, and its position recorded. The angle be-

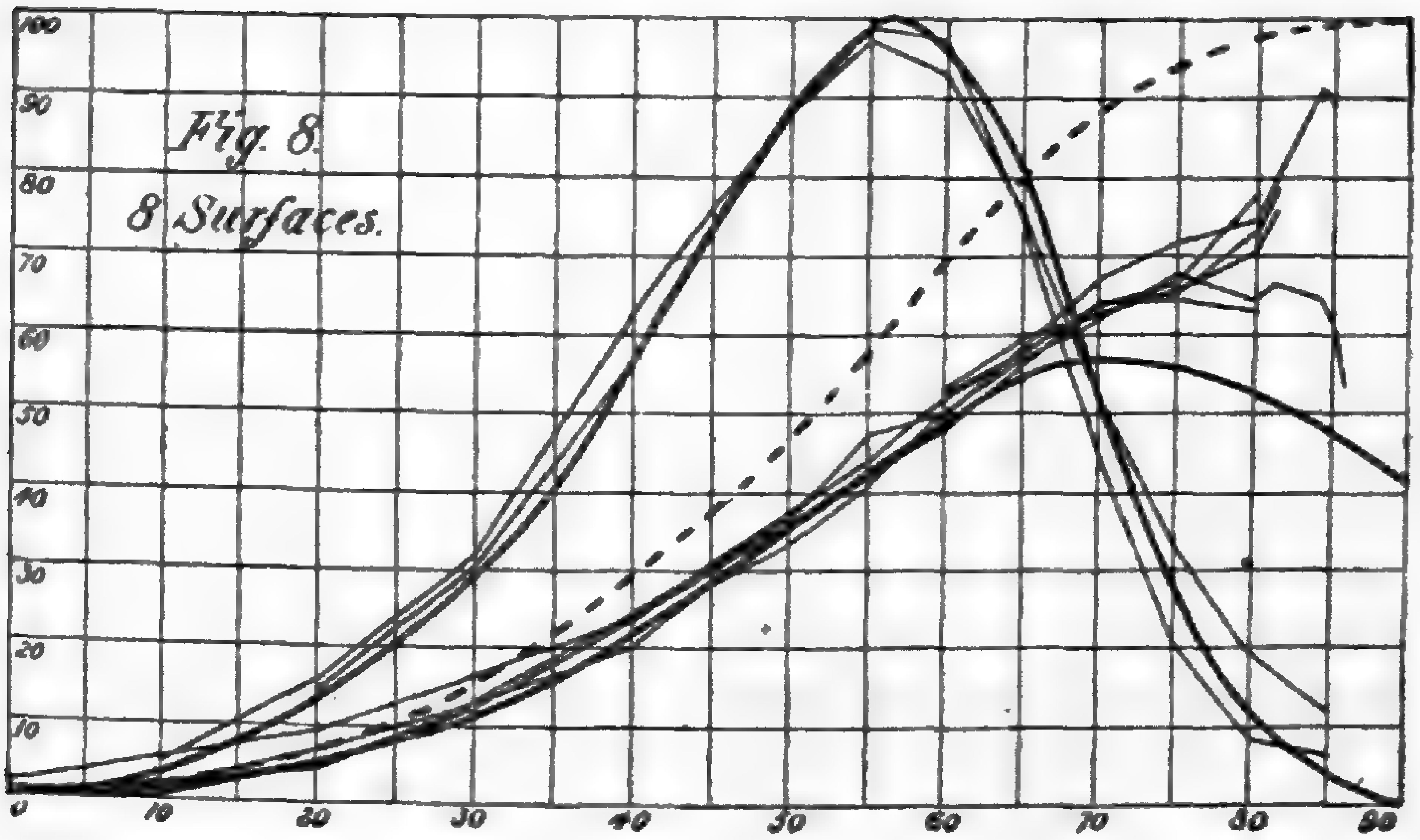


Fig. 8.
8 Surfaces.

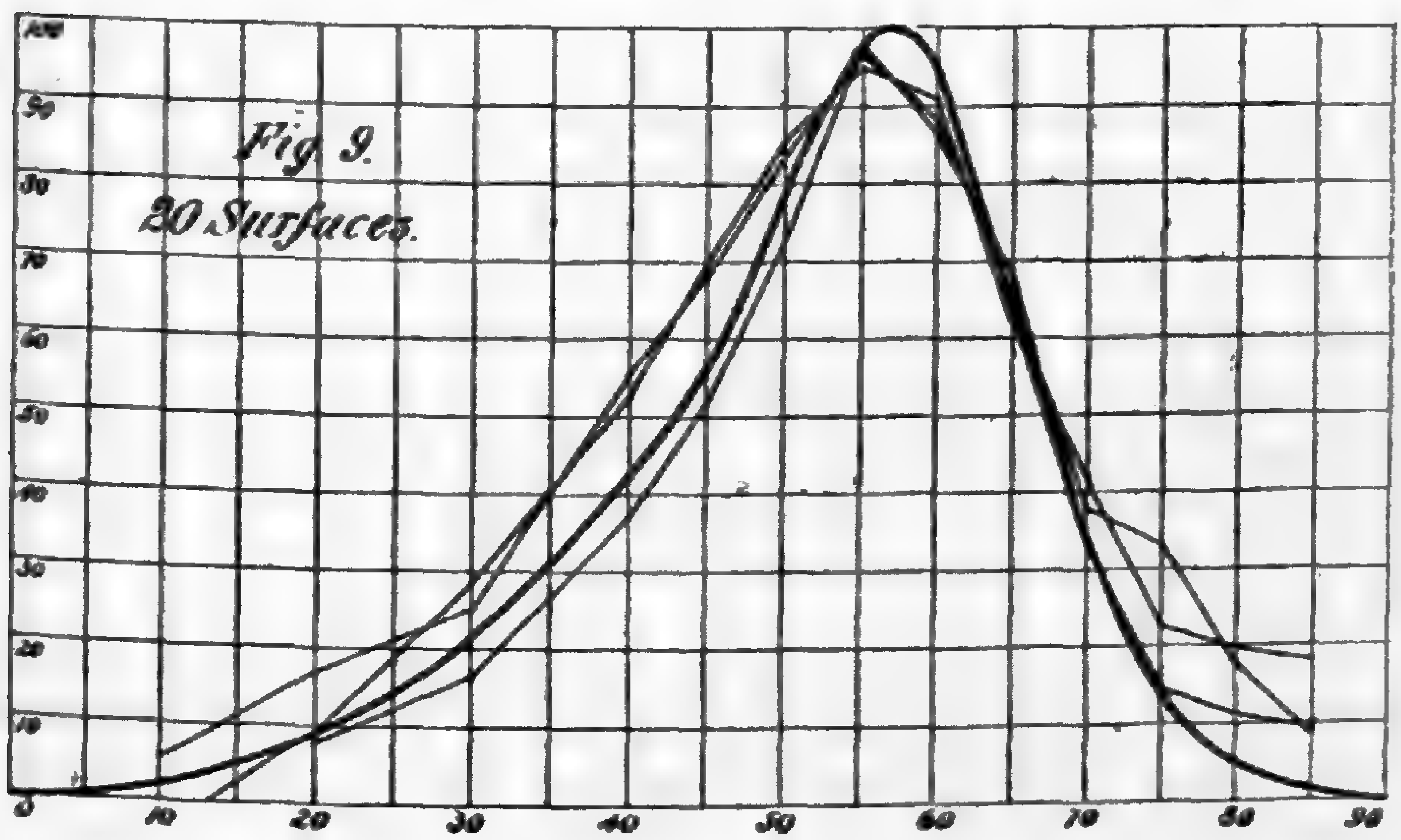


Fig. 9.
20 Surfaces.

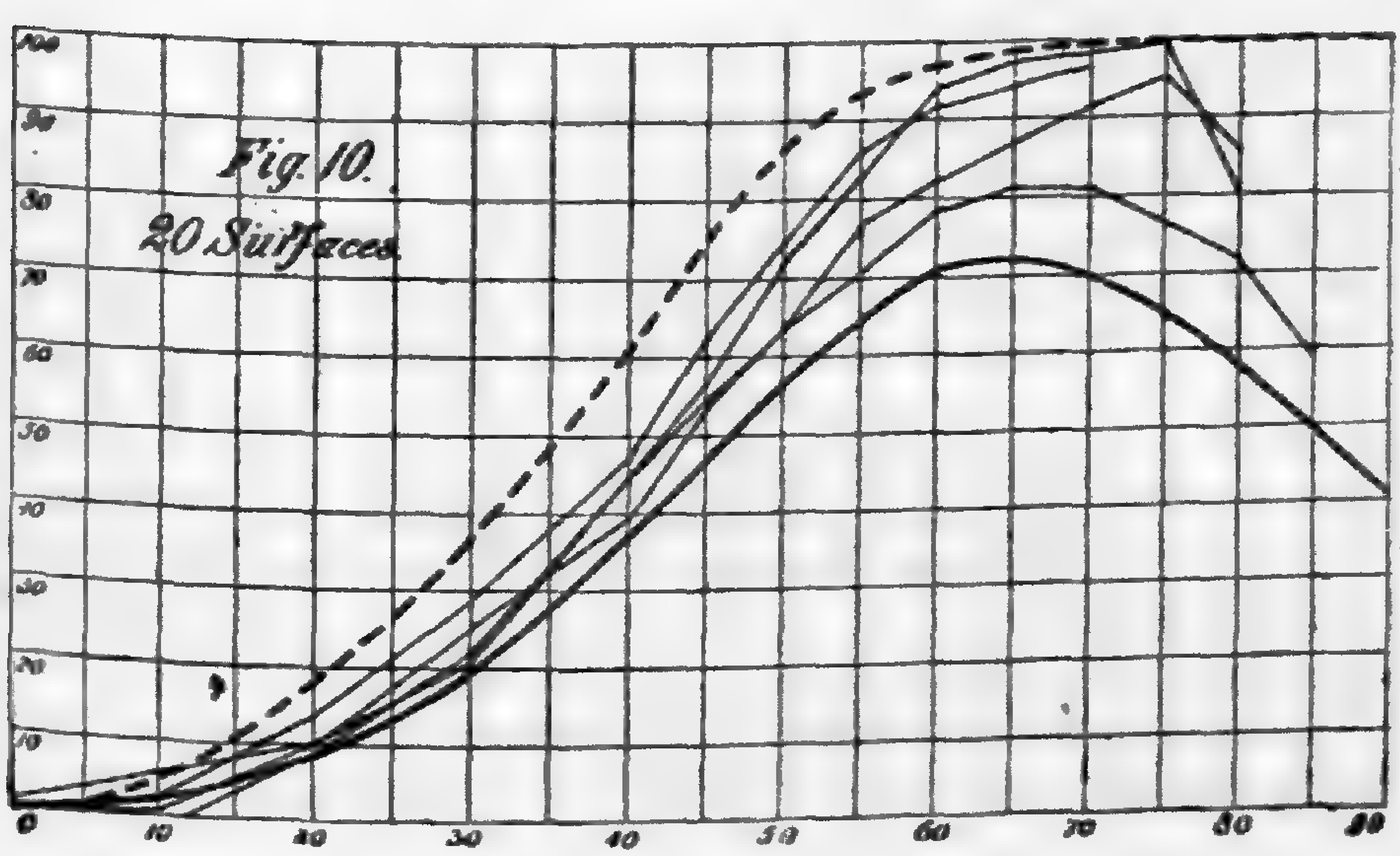


Fig. 10.
20 Surfaces.

tween the telescopes is then altered so as to make i successively 10°, 20°, 30°, &c., and the observation repeated. Various adjustments must be made to eliminate constant errors, but they need not be detailed here. One series was made with a glass prism having an index of 1·52, a second with a plate of colored glass, a third with a sheet of plate glass and others with four and ten microscope slides. The latter were used, as the thickness of the plate-glass was such that, when a number of plates were placed between the telescopes, a portion of the internal reflection would be lost.

To measure the polarization by refraction, two similar methods were employed. The plates were placed vertically over the center of a graduated circle, and a piece of ground-glass was viewed through them by the polarimeter. The plates were then set at various angles, and the polarization measured in each case. All these observations were made in cloudy weather, to eliminate the effect of sky polarization. Several series were made with the optical circle and Babinet's wedges, placing the telescopes opposite each other, and recording the angles of the Nicol for various positions of the plates. Still a third method was employed, already described in connection with the Arago's polarimeter.

It will be noticed that no observations are given of the polarization of a beam transmitted by one surface of glass. There seemed to be no easy method of measuring this quantity. It might be done by making a series of prisms of such angles that when the light was incident on one face at 10°, 20°, 30°, &c., the refracted ray would strike normally on the second face. The effect of the latter would then be nothing, so that the polarization would in this case be entirely due to the first surface.

To determine the polarization of a single surface of glass a plate was covered on one side with lamp-black, but it was found to give the same results as when laid on velvet. A plate of colored glass was therefore used instead. Fig. 6 gives the results of the observations of the polarization effected by one surface of glass, fig. 7, that of two surfaces, fig. 8, of four, fig. 9, the reflected beam for twenty surfaces, and fig. 10 the corresponding refracted beam. The smooth curves give the theoretical polarization, including the internal reflection, and the dotted lines omitting it. The observations of the reflected beam agree very well with theory, especially when the number of surfaces is small. The refracted beams, on the other hand, show a deviation from theory which becomes perceptible for one plate above 80°, for four plates above 65°, and for ten plates above 20°. The errors most likely to occur, which would be common to all the observations on the refracted beams, are, first, stray light, or light entering the instrument without passing through the glass; secondly, light passing through the glass endwise, which might be recognized by its deep green color; and, thirdly, light reflected from the front surfaces of the plates. But all these errors would tend to diminish, instead of increase, the polarization; and hence, if eliminated, the divergence from theory would be still greater. Probably the true explanation is that internal reflection does not take place as completely as theory assumes, partly owing to the imperfect transparency of the medium, and partly to the dust and other impurities on the surface. It makes but little difference for the reflected rays, the polarization being the same for three values of i, namely, 0°, 57°, and 90°. For the refracted ray, on the other hand, the variations are very great, amounting in the case of twenty surfaces, at 90° incidence, to over 50 per cent. From the dotted lines we see that a partial absence of the internal reflection would account for all the results obtained, while neglecting it entirely would cause a still greater divergence between theory and observation.

On account of the thickness of the bundle of ten plates of glass, a portion of the secondary reflection would be thrown a considerable distance to one side, especially when i is large, so that it might fall quite outside of the instrument, or even be cut off by the ends of the plates. This effect would be least marked with the polarimeter, next with the Savart, and most of all with the optical circle, on account of the small aperture of the telescope. But this is just the order in which the observations stand, all of them falling between the two theoretical curves. These observations also show the effect to be expected from a bundle of plates when used to polarize light by refraction. If ten plates are employed, set, as is usual, at 57°, the polarization would be only 67·2 per cent if internal reflection takes place, but would be 95·2 if this is in any way excluded. We may, in passing, point out that an advantage might be expected in such a polariscope from an increase in the angle of incidence, the increased polarization probably more than making up for the loss of light and distortion induced by the increased obliquity of the incident rays.

The want of perfect transparency of the glass would also tend to increase the polarization by enfeebling the secondary reflection, and dirt or grease on the surface of the glass would produce the same effect. With eight and two surfaces, these disturbing causes are much less marked, except for large angles of incidence, and hence the agreement with theory much better.

ART. XV.—*On the Dissipation of Electricity in Gases;* by DEMETRIEFF BOBOULIEFF.

[Translated from the Journal of the Russian Chemical and Physical Societies, by CLEVELAND ABBE.]*

THERE are, according to the general statement, four forms of electrical discharge manifested in gases. Three of these are accompanied by luminous manifestations, and the sudden loss of electricity; these are the following:

1. Discharge as an electrical spark.
2. Discharge as a luminous sheet.
3. Discharge as a kind of diffused light (Glimmlicht).
4. A discharge without any light, and as a gradual slow loss; this latter case is called dissipation (rassyania, dêperdition, zerstreuung) of electricity.

Coulomb has paid special attention to this dissipation, and the circumstances affecting the investigation into the distribution of electricity on conducting bodies. He has given a formula expressing the connection between the quantities Q_0 and Q of electricity, found in a given body, at the beginning and the end of an interval, *t*, of time, during which the dissipation continues; which is

$$(1) \qquad Q = Q_0 e^{-\frac{t}{2p}}.$$

The quantity $\frac{1}{p}$ is called the coefficient of dissipation; when it diminishes, i. e., when p increases, then the dissipation is slower, and *vice versa.*

Coulomb, making his observations in ordinary moist air, observed that the quantity $\frac{1}{p}$ was very changeable. This might arise from the changes of temperature or of atmospheric pressure, and the pressure of the aqueous vapor. Coulomb paid special attention to the action of aqueous vapor, and expressed his opinion that $\frac{1}{p}$ varies as the cube root of the quantity of vapor contained in a given volume of air. Many others after him have engaged in experiments to determine this connection between the coefficient of dissipation and all the above quoted causes; but the results of these labors harmonize but very little.

I give here, in consecutive order, the conclusions of all the following savants:—

* I have to acknowledge the assistance of Mr. H. Kalusoski in the preparation of this somewhat free translation of M. Boboulieff's interesting memoir.—C. A.

Matteuci: Memoire sur la propagation de l'électricité dans les corps isolants, solides et gazeux. Annales de Chimie et de Physique, 3me Serie, vol. xxviii, pp. 385–429.

Dellmann: Ueber die Gesetzmässigkeit und die Theorie des Electricitätsverlustes. Zeitschrift für die Mathematik und Physik, von Schlömilch, Kahl und Cantor, xi, 1866, pp. 325-354.

Charault: Recherches sur la dêperdition de l'électricité statique par l'air et les supports. Comptes Rendus, vol. l, pp. 108–111.

Warburg: Ueber die Zerstreuung der Elektricität in Gasen. Poggendorff's Annalen, B. cxlv, s. 578–599.*

1. *Of the Coulomb's Law expressed in the formula* (1).

Matteuci (p. 390) says: "The dissipation of electricity in pure and very dry air and gases† does not follow the formula and laws of Coulomb." He determined his law by experiments carried on in damp air; within certain limits, the dissipation is certainly not in proportion to the quantity of electricity "contained in the body."

Dellmann (p. 336): "The absolute dissipation is proportional to the density of the electricity; that is, it is according to Coulomb's law."

Charault: "The dissipation always follows Coulomb's law."

Warburg: "The dissipation of electricity in gases follows Coulomb's law."

2. *Influence of surrounding bodies.*

Matteuci (p. 389): The dissipation of the electricity depends upon the electric condition of the bodies found near the body under examination; the smallest loss is experienced when the neighboring bodies are charged with an electricity opposite to that in the body under examination.

Charault says: "The dissipation follows Coulomb's law in limited and unlimited spaces."

3. *The influence of the movement of the gases.*

Matteuci says (p. 386): "The dissipation does not increase when the air is in motion, but, on the contrary, it diminishes; and furthermore, this diminution is in proportion to the velocity of the movement of the air in relation to the body, and to the amount of the dissipation itself."

Dellmann (p. 345): "The dissipation does not depend on the motion of the air."

* Received in Russia while the author was engaged in making his own experiments on the subject.

† The electrical dissipation for an interval dt is, according to Coulomb's law,

$$dQ = -\frac{Q}{2p}\,dt.$$

4. *Influence of the size, configuration and conductibility of the body.*

Reiss* (pp. 111–113): "The dissipation does not depend on these circumstances."

Matteuci (p. 406): "The laws and the amount of the dissipation are independent of the matter of the bodies."

Dellmann (p. 344): "The dissipation does not depend on the size, form and matter of the electrified body." (p. 346): "The dissipation is the same in conductors and non-conductors."

5. *Influence of the kind of electricity.*

Biot, repeating Reiss's experiments, came to the same opinion,† "that the coefficient of dissipation does not depend on the sign of the electricity."

Matteuci (p. 408): "The dissipation and its laws are the same for both kinds of electricities, as well in dry gases as in the air; but in strongly charged bodies the negative electricity disappears much sooner."

Dellmann (p. 346): "The dissipation does not depend on the sign of the electricity."

Warburg (p. 599): "The dissipation of electricity of both signs is completed with the same rapidity."

6. *Influence of the temperature.*

Matteuci (p. 411): "In dry air the dissipation augments with increased temperature."

7. *Influence of humidity.*

Reiss‡ testifies: "That occasionally the dissipation diminishes with the increased dampness of the air."

Matteuci (p. 421): "In air of the same temperature, and under the same pressure, the dissipation increases with the quantity of suspended aqueous vapor; but this augmentation does not increase in proportion to the cube of the suspended vapors, as concluded by Coulomb from his too few experiments."

Dellmann (p. 541): "The dissipation does not depend on the percentage of moisture in the air, but on the quantity of the vapor included in one cubic foot of the air; and in proportion to the increase of this quantity, the dissipation increases."

Besides this, Dellmann adds: "that the dissipation is especially determined by the pressure of the aqueous vapor."

Charault says: "In dry air the coefficient of dissipation is very small compared with that for damp air. The coefficient increases with the increase of the dampness of the air, if the

* Die Lehre von der Reibungs electricität, Bd. i, s. 106–147.
† Riess, Bd. i, pp. 113–114.
‡ Reiss, Reibungs electricitat, p. 117.

quantity of vapor in the given volume remains the same. The coefficient of dissipation* increases with the increase of the quantity of vapor.

Warburg: "Damp air does not cause greater dissipation than dry air."

8. *Influence of the pressure.*

Matteuci (p. 415): "The quantity of electricity that may be retained on the surface of an isolated conductor depends on the density of the surrounding air. In a vacuum this quantity is nothing. The dissipation in dry air diminishes with the diminution of the density."

Warburg (p. 599): "The coefficient of dissipation sensibly diminishes when the pressure falls from 760^{mm} down to 380^{mm}, and at the pressure of 70^{mm} is less than one-third of what it was at 760^{mm}."

9. *Influence of various gases.*

Matteuci (p. 403): "In the air, hydrogen and carbonic acid, dry and pure, having the same pressure and temperature, the dissipation is the same."

Warburg: "Dissipation is the same in the air and carbonic acid, but in hydrogen one-half as great."

10. *Influence of tobacco smoke, etc.*

Dellmann (p. 346): "Dissipation diminishes in the presence of tobacco smoke."

Warburg (p. 594) supposes "that the hard particles floating in the air exercise some influence."

On my own part, on entering into the investigation of this same subject, relative to which I have quoted so many differing data, I was assisted by some theoretical conclusions which I think I can here explain.

Not only certain authorities in physical sciences, but even several specially devoted to electrical researches, sustain the view that electricity adheres only to the surface of conducting bodies by the counter-action or coöperation of the air in contact.† Such a theory would make us believe that in a vacuum the electricity meeting no force to oppose it would leave the surface of the electrified body, and would evaporate, as it were, in empty space until it extended to the walls of the enclosing cover or vessel, and subsequently be neutralized by contact with an electricity of an opposite sign. But many experiments

* Charault says, the dissipation in both cases decreases with the volume, thus:

$$a = \frac{1}{e^{2p}}.$$

† De la Rive, Traite de l'Electricité, T. i, p. 121.

tried at different times prove that gases even of the smallest density, and under the pressure of even less than 70^{mm}, can become under certain conditions conductors of electricity, and the first three of the above classes of electrical discharge may be observed through them;* but an absolute vacuum does not conduct electricity.†

On the other hand, it is impossible to deny all reaction on the part of the air, which is illustrated, for instance, by the movement of "Franklin's wheel."‡ But such a reaction may be derived from such atoms only as, after receiving electricity by contact with the electrified body, are repelled from it; of course, the magnitude of such reaction is very inconsiderable,§ but nevertheless it is accompanied by the other manifestation, that is, the loss of the electricity.

The atoms having received from the body a portion of its electricity, carry it away as they retire, and distribute it to other bodies, either electricized with an opposite electricity or having some direct connection with the earth. This constitutes in general the process of the loss of electricity by the agency of the gases, or the partial dissipation. Such, at least, is the opinion of almost all.‖ At present, when the new theory of the constitution of gases is accepted, such an explanation of the origin of electrical dissipation inspires hope that the subsequent development of electrical statics will aid in explaining the electrical manifestations observed in gases, and particularly the discharge of electricity, whether by sparks or by silent discharge; and the dependence of the electrical conductibility of the gases on the atmospheric pressure.

Accepting the hypothesis of atomic motions in gases, it will be easy to demonstrate that the dissipation of electricity depends on the pressure of the gas; and if we disregard certain circumstances we will find that,

1. Dissipation follows according to Coulomb's law.

2. The coefficient of dissipation, $\frac{1}{p}$, is inversely proportional to the square root of the absolute temperature of the gas.

3. That it is proportional to the pressure of the gas.

4. That it depends on the nature of the gas.

* Reiss, Reibungs electricität, B. i, pp. 39, 40; Morren, Pogg. Ann., B. 130, pp. 631, 633.

† Reiss, Rebungs electricität, B. i, pp. 39, 42; Alvergniat, C. R., Tome xlv, p. 963; Pogg. Ann., cxxxiii, p. 191; Wüllner, Pogg. Ann., cxxxiii, p. 509.

‡ In a vacuum this does not move.—Tomlinson, Phil. Mag. (4), xxvii.

§ Kötteritzsch attributes the amount of this reaction to a difference that exists between the results of the experiments of Harris and the computation of Thomson.—See Electrostatik von Kötteritsch, pp. 316–327.

‖ Reiss, Reibungs-electricität, vol. i, p. 108; Dellmann, Ueber die gesetzmässigkeit. . . . Zeitschrift f. Math., xi, pp. 348, 349; Matteuci, Memoire sur la propagation de l'electricité, Ann. de Chim. et de Phys. (3), T. xxvii, p. 171.

The new theory of the gases assumes that perfect gases are composed of atoms found in a state of perpetual motion. Each atom must be considered as a center of atomic force, whose tension diminishes in proportion to the separation of the atoms in such a manner that beyond the limits of a certain sphere the atomic force of the atom at its center becomes so insignificant that it can be considered to be nothing. This sphere is called the sphere of atomic action. The volume occupied by the sphere of any atom found in a given volume of gas is indefinitely small in comparison with the volume of the gas.

The motion of each atom is in a straight line and with a uniform velocity, and so continues as long as it does not bring the atom into contact with the sphere of another atom, or until one interferes with the action of the other; when this happens there results a change of motion of both atoms—a sort of concussion, after which each atom has a new direction and a new velocity. Such a concussion is similar to the striking of elastic balls, and is performed in an infinitely short time. The same thing is experienced in the concussion of particles or balls of any kind of hard bodies.*

If among such a collection of moving atoms there be placed an electrified body, the motion of all the atoms will change, because on each of them will operate a new force, the amount and direction of which will depend on the form of the electrified body, the quantity of its electricity, the distance of the atoms from its surface, and even the size of the atoms themselves; in general this force will attract the atoms to the body; but as these atoms are very small and the quantity of electricity in them almost nothing, therefore the force acting on the atoms will be very inconsiderable, and at a distance from the surface of the electrified body will be so insignificant that in the first moments of time the change in the motions will scarcely be marked, except for those atoms which come in contact with each other.

Let, for instance, the electrified body be a metallic ball whose radius $=\mathrm{R}$; the quantity of its electricity $=\mathrm{Q}$; each atom suffers an electrical induction depending on the action of the ball R, and the action of other neighboring bodies; omitting for the present the action of the last, we find that the force operating on the atoms (represented also by their radius$=r$) in the direction from the center of the atom to the center of the body, is equal to $\frac{d\mathrm{W}}{dc}$ where†

* Clausius: Abhandlungen über die Mechanische Wärme Theorie, II, pp. 235, 261; Maxwell, Illustrations of the Dynamical Theory of Gases, Part I. Phil. Mag. (4), xix, pp. 19, 20.

† Considering the state of distribution of the electricity on two spheres under the influence of minute electrical forces.

$$\text{(2)} \qquad W = -\frac{Q^2}{2}\left\{\frac{1}{R} - \frac{r^3}{c^4}\right\},$$

and c is the distance between the centers of the ball and the atom; the equation (2) is obtained by disregarding higher powers of the fractions, as for instance $\frac{r}{c^2 - R^2}$ and $\frac{rR}{c^2 - R^2}$; which is allowable only in case $(c - R)$ is much greater than r.

Let us now see what will be the effect of such a force on the duration of the interval between two consecutive concussions. To this end let the velocities be u_0 and u; the distances of the center of the atom from the center of the electrified conductor at the beginning and the end of the interval be c_0 and c; then if we consider the living forces we find

$$u^2 - u_0^2 = \frac{Q^2 r^3}{m}\left(\frac{1}{c^4} - \frac{1}{c_0^4}\right).$$

Let us put $c = c_0 \pm nl$ where $l = \frac{1}{10000}$ of a millimeter, or the average length of the path between the concussions of two atoms;* and n is an abstract number of such value that the ratio $\frac{nl}{c}$ represents a small fraction, so that we can put

$$\frac{1}{c^4} - \frac{1}{c_0^4} = \pm\frac{4nl}{c_0^5};$$

thus we have

$$\text{(3)} \qquad u^2 - u_0^2 = \pm\frac{4Q^2 r^3 nl}{mc_0^5}.$$

The quantity m, the mass of the atom, can be expressed thus:

$$m = \frac{P}{Ng} = \frac{1}{Ng}\cdot\frac{\delta d H}{(1+\alpha t)760};$$

where P is the weight of the unit of volume of the gas; N is the number of atoms in said volume; $\delta = 0{\cdot}001293$ milligram is the weight of one cubic millimeter of air at 0° C. and 760^{mm}; H is the actual pressure of the gas; t is the temperature; d is the density of the gas as compared with air; $g = 9800^{mm}$ is the force of gravity expressed as a velocity per second.

Furthermore,†

$$N = \frac{1}{\lambda^3} = \frac{3}{4}\cdot\frac{1}{\pi\rho^2 l};$$

where λ is the mean distance between the atoms; ρ is the radius of action of the atoms. If now we indicate by $\Delta = \frac{Q}{4\pi R^2}$ the density of the electricity, i. e., the quantity belonging to one

* Clausius, Abhandlungen, II, p. 325.

† Clausius, Abhandlungen, II, p. 272.

square millimeter of the surface, then we will be able to write formula (3) in the following form:

$$u^2 - u_0^2 = \pm 48\pi \frac{R^4}{c_0^4} \cdot \frac{r^3}{c_0 \rho^2} \cdot \frac{g760(1+\alpha t)}{\delta \cdot d \cdot H} \Delta^2 n =$$

$$\pm 1142927000 \frac{R^4}{c_0^4} \cdot \frac{r^3}{c_0 \rho^2} \cdot \frac{760(1+\alpha t)}{d H} . \Delta^2 n.$$

To show how insignificant is the second part of this equation, we will make the following disadvantageous suppositions:

$$r = \frac{\rho}{10}; \quad \rho = \frac{l}{10^3}; \text{ where } r = \frac{1}{16 \times 10^7}; \quad c_0 = R;$$

and lastly, if for simplicity we put $t=0$, $H=760^{mm}$, $d=1$, for which there results* $u_0 = 485 \times 10^3$ millimeters, we obtain

$$u^2 = u_0^2 \left(1 \pm \frac{\Delta^2 n}{R} \cdot \frac{311}{10^{15}}\right)$$

or

$$u = u_0 \left(1 \pm \frac{\Delta^2 n}{R} \cdot \frac{155}{10^{15}}\right).$$

If we put $R = 10^{mm}$, $\Delta = 10^3$, $n = 10^5$, which correspond well to a very strong tension of the electricity† and to a length of the path nl of six millimeters, we then obtain

$$\frac{u}{u_0} = 1 + 0{\cdot}00155.$$

This change in the velocities will correspond to a change in the temperature of 0°·8 C. It follows that during the first moments there will fall on the surface of the electrified body—

1. Such atoms as would fall on it in case it were not electrified, and in consequence of gravity alone.
2. Such as are very near to the surface.
3. Such as may from greater or less distances accidentally pursue their paths past each other without concussion.

After the first moment, during which the falling atoms become electrized, they retire from the surface of the body and meet the non-electrized atoms, and communicate to the latter a part of the electricity received from the body; hence many atoms will remain at the surface of the body, and they will be charged with the same kind of electricity. The force acting on such atoms will direct them *from* the surface of the body, while the force acting on the neutralized atoms will attract them *toward* its surface: the former will diminish the number of atoms falling toward the body; the latter will increase that number.

* Clausius, Abhandlungen, II, p. 255.

† Compare Weber and Kohlrausch, Maassbestimmungen, Zurückführung der Stromintensitäts Messungen auf Mechanisches Maass., p. 263.

As the result of these considerations we must admit that *during the slow dissipation of the electricity the number of atoms dropping on the surface of the electrified body is nearly such as is determined by the pressure and temperature of the gas found nearest to the surface.*

According to Maxwell* the number of atoms adhering in a given unit of time to a given unit of surface is

$$\int_0^\infty dn \int_0^{n} \frac{nl-z}{2nl} \cdot \frac{Nu}{l} \cdot e^{-n} dz = \frac{Nu}{4};$$

where l and u are respectively the mean length of path and the mean velocity of the atom; N is the number of atoms in the unit of volume of the gas; z is the coördinate whose axis is normal to the surface; n, an abstract number, either whole or fractional, included between zero and infinity.

The number of atoms falling in the elementary space of time dt on the element ds of the surface of the body will be

$$\frac{Nu}{4} ds\, dt;$$

hence the number of atoms dropping in the time dt on the whole surface of the sphere R will be

$$\pi N u R^2 dt.$$

Each atom on striking the sphere will receive a quantity g of electricity, expressed by the equation†

$$g = \frac{\pi^2}{6} \cdot Q \frac{r^2}{R^2};$$

consequently the ball in the time dt will lose a quantity of electricity equal to

$$\frac{\pi^3}{6} N u Q r^2 dt;$$

that is to say,

$$dQ = -\frac{\pi^3}{6} N u Q r^2 dt;$$

whence, assuming N and u to be constant, we obtain by integration the formula of Coulomb:

$$Q = Q_0 e^{-\frac{t}{2p}};$$

in which the coefficient of dissipation will be

$$\frac{1}{p} = \frac{\pi^3}{3} N u r^2.$$

* Maxwell, Illustrations, Phil. Mag., vol. xix, p. 29.
† Reiss, Reibungs electricitat, vol. i, p. 226.

In order to demonstrate the dependence of this expression on the pressure of the gas, we will make use of the following:*

$$u = 485 \times 10^{3} \sqrt{\frac{1+\alpha t}{d}}; \qquad Nm = \frac{\delta d H}{g \cdot 760 \cdot (1+\alpha t)},$$

where the letters have the same meaning as before; we then obtain:

$$(4) \qquad \frac{1}{p} = \frac{\pi^{3}}{3} \cdot \frac{\delta}{g} \cdot 485 \cdot 10^{3} \cdot \frac{r^{2}}{m} \cdot \frac{H}{760} \cdot \sqrt{\frac{d}{1+\alpha t}},$$

that is to say, the coefficient of dissipation in one and the same gas increases in proportion to the pressure.

Taking this conclusion for my base,† I undertook to investigate experimentally the dependence of the coefficient of dissipation on the pressure and properties of the gas. The apparatus that I used was constructed in the following manner:

On the copper plate of an air pump was fixed a bell glass, with an opening in its upper part. Into this opening a diaphragm was adapted, having a sliding tube plastered carefully, through which passed a copper rod, having at its upper end a glass handle, and at its lower end a curved prolongation ending with a small sphere. To the diaphragm there was attached a silk thread, from which hung by the middle a little bar (MN) made of shellac, about 100^{mm} long and 1^{mm} diameter, having on one of its ends a little ball made of elder pith covered with gold leaf, and on the other a small leaf of mica; by the middle of this bar again was fixed, also of shellac, a little rod 40^{mm} long and 2^{mm} diameter, carrying at its lower end a short magnetized needle. (*mn*). The ball was immovable, and of the same diameter as the movable one. On the outside of the bell glass on a level with the bar was pasted a scale (BB) on thin paper, divided on both sides into degrees. The position of the bar was observed from a distance of 1·5 meters from the bell glass by bringing the eye into a line with the silk thread and the corner of the mica sheet.

The air or gases were introduced into the bell glass through five drying tubes, of which one was filled with small pieces of pumice stone, wetted with sulphuric acid, and another with chloride of calcium; under the bell glass stood a small vessel containing pieces of phosphoric acid. The experiments were performed only after the bell glass had been at least three times refilled with such air or gas.

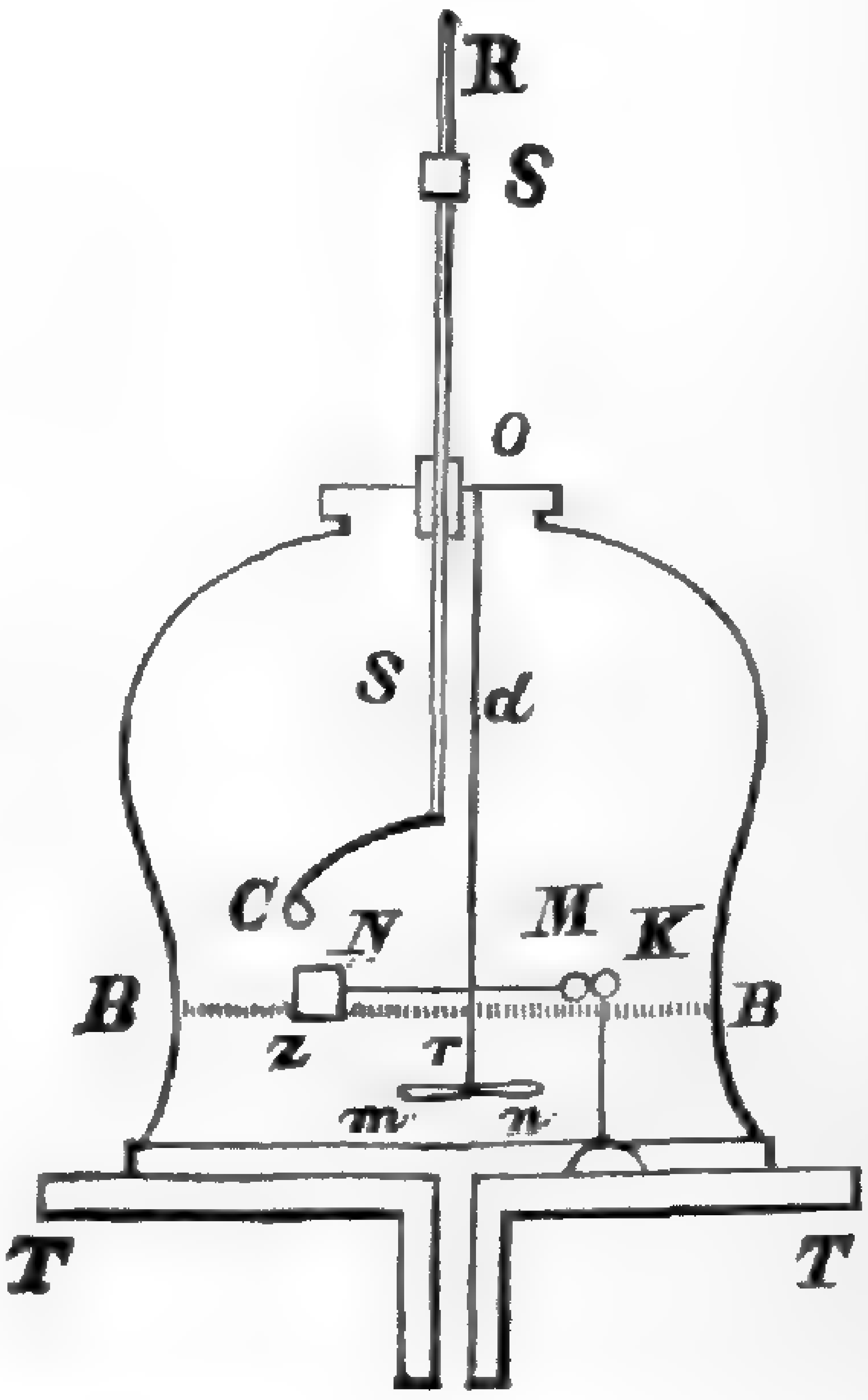
The shaft or copper rod served to charge the balls, which before being charged touched each other; in this position the

* Clausius, Abhandlungen, II, p. 255.

† Dellmann comes to the same conclusions as to the quantity of water in the air. Zeitschrift für die Mathematik und Physik v. Schlömilch. Band xl, s. 348–352.

bar which supported the needle was in the magnetic meridian. When the balls are each charged with the same quantity of electricity, the bar MN will deviate by the angle a_0; then the moment of the repulsion of the electrical forces may be expressed thus:

$$\frac{Q^2}{4L^2 \sin^2 \frac{1}{2}a_0} L \cos \frac{1}{2}a_0;$$



and the moment of the magnetic force,

$$MT \sin a_0,$$

where L is the half length of the bar; M the magnetic moment of the needle *mn*, and T the intensity of terrestrial magnetism. Equating both expressions we obtain:

$$(5) \qquad Q_0^2 = 8MTL \sin^3 \tfrac{1}{2}a_0.$$

After the lapse of the time *t*, the quantity of electricity will become Q, and the angle of deviation will be a:

$$(6) \qquad Q^2 = 8MTL \sin^3 \tfrac{1}{2}a.$$

Eliminating the quantities Q and Q_0 from the equations (1), (5) and (6), we obtain:

$$(7) \qquad p = \frac{t \log e}{3(\log \sin \frac{1}{2}a_0 - \log \sin \frac{1}{2}a)}.$$

According to this formula I have computed p.

I am certain that each time I read the divisions on the paper scale BB, I could not make an error greater than one-half of a degree. The angle a_0 or a is the mean of four observed numbers; if in the neutral state of the balls I read the divisions X and X_1, and when they were electrified, the divisions Y and Y_1, then a is equal the half sum of the differences $X-Y$ and X_1-Y_1. In each of these four readings I could not commit an error of one-half of a degree; consequently the largest error in the determination of the angles $\frac{a}{2}$ and $\frac{a_0}{2}$ could amount only to $\frac{4}{4} \cdot \frac{1^\circ}{2} = \frac{1^\circ}{2}$.

If $\frac{1}{2}a$ and $\frac{1}{2}a_0$ be varied $\pm 30'$, then the log sin $\frac{1}{2}a_0$ and log sin $\frac{1}{2}a$ will vary, which I indicate thus:

$$\Delta \log \sin \tfrac{1}{2}a_0 \text{ and } \Delta \log \sin \tfrac{1}{2}a;$$

as a consequence of this, p will change to Δp; and we have

$$\frac{p+\Delta p}{p}=\frac{\log\sin\frac{a_0}{2}-\log\sin\frac{a}{2}}{\log\sin\frac{a_0}{2}-\log\sin\frac{a}{2}+\Delta\log\sin\frac{a_0}{2}-\Delta\log\sin\frac{a}{2}}$$

from this we obtain:

$$\frac{\Delta p}{p}=-\left\{\frac{\Delta\log\sin\frac{a_0}{2}-\Delta\log\sin\frac{a}{2}}{\log\sin\frac{a_0}{2}-\log\sin\frac{a}{2}}\right\}+\ldots.$$

where we see that the term expressed in the parenthesis is less than unity.

In the worst case, when $\Delta\log\sin\frac{a_0}{2}$ and $\Delta\log\sin\frac{a}{2}$ have opposite signs, we have for the greatest value of $\frac{\Delta p}{p}$

$$(8)\qquad \frac{\Delta p}{p}=\pm\frac{\Delta\log\sin\frac{a_0}{2}+\Delta\log\sin\frac{a}{2}}{\log\sin\frac{a_0}{2}-\log\sin\frac{a}{2}}$$

According to this formula I have computed the greatest possible error in the determination of the quantity p in my experiments; and have selected only those results in which $\frac{\Delta p}{p}$ is not more than 0·3: the rest I have rejected.

The electrical condition was maintained from eight to ten days, as for instance, from 30th June to 10th July, and in another case from 22nd June to 30th June.

The following are the results obtained:

I. *In dry air at the ordinary pressure.*

No.	Month.	Day.	Hour. P. M.	t	$\frac{a_0}{2}$ or $\frac{a}{2}$	$\frac{\Delta p}{p}$	p
1	July	12	1h 38m	----	7° 15′	----	----
	"	12	7 20	342m	2 45	0·2	118
2	"	20	7 57	----	20 52·5	----	----
	"	21	1 40	1063	4 52·5	0·08	247
	"	21	3 37	1180	2 7·5	0·09	174
3	August	14	1 15	----	19 0	----	----
	"	14	3 34	139	15 30	0·28	238
	"	14	4 2	167	15 7·5	0·25	251
4	"	18	4 38	----	19 30	----	----
	"	18	7 5	147	13 45	0·17	144

II. *In dry hydrogen under the ordinary pressure.*

No.	Month.	Day.	Hour. P. M.	t	$\frac{a_0}{2}$ or $\frac{a}{2}$	$\frac{\Delta p}{p}$	p
1	July	13	4h 30m	----	13° 0′	----	----
	"	14	1 0	1230m	7 30	0·17	753
2	"	22	3 40	----	17 30	----	----
	"	23	12 50	1270	12 0	0·18	1147
	"	23	3 10	1410	11 15	0·16	1086
	"	23	6 37	1617	10 15	0·14	1027
	"	24	12 27	2693	3 22·5	0·10	542
3	"	26	2 25	----	14 7·5	----	----
	"	26	8 3	458	11 22·5	0·35	716

III. *In dry air at pressures between* 24mm *and* 50mm.

No.	Month.	Day.	Hour. P. M.	t	$\frac{a_0}{2}$ or $\frac{a}{2}$	$\frac{\Delta p}{p}$	p	Pressure.
1	June	30	4h 0m	----	12° 30′	----	----	24mm
	July	1	4 0	1440m	9 15	0·3	1613	--
	"	2	1 30	2730	8 22·5	0·24	2297	--
	"	3	12 45	4125	7 15	0·18	2549	--
	"	4	2 10	5650	6 22·5	0·17	2822	25
	"	5	1 0 P.M.	7020	5 7·5	0·14	2644	--
	"	6	11 40 A.M.	8380	4 7·5	0·13	2536	28
	"	7	12 30 P.M.	9870	2 37·5	0·14	2118	32
	"	8	1 15	11355	1 45	0·15	1933	34
2	"	29	2 0	----	6 45	----	----	25
	"	30	2 46	1486	3 52·5	0·3	895	45
3	August	5	4 1	----	13 30	----	----	23
	"	6	1 4	1263	8 7·5	0·2	879	55
4	"	7	2 42	----	16 7·5	----	----	48
	"	8	12 57	1335	10 45	0·18	1117	55
	"	9	1 9	2787	5 52·5	0·1	937	65
5	"	15	4 33	----	15 30	----	----	34
	"	16	3 13	1360	10 52·5	0·2	1302	40
	"	17	2 34	2761	7 37·5	0·13	1312	45
	"	18	3 15	4242	3 52·5	0·11	1028	50
6	"	19	2 30	----	13 0	----	----	34
	"	20	6 6	1356	9 0	0·2	1244	35

The mean of Series

I, Air under pressure of 760mm, $p=210$
II, Hydrogen under pressure of 760mm, $p=878$
III, Air under pressure of 30–50mm, $p=1700$

I conclude from this:

1. That the dissipation of electricity in air (and other gases) diminishes with the diminution of the pressure.

2. That the dissipation in hydrogen is less than in air [at the same pressure].

ART. XVI.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XXVII.—*Results of recent Dredging Expeditions on the Coast of New England.* No. 5; by A. E. VERRILL.

[Continued from page 46.]

THE shores of the islands and of Cape Elizabeth afford excellent collecting grounds at low water, owing to their diversified character. A large part of these shores are abrupt and rocky, and often formed of broken and precipitous ledges of hard metamorphic slates and thin-bedded grits, or altered sandstones, in some places passing into gneissose rocks, and generally dipping at a high angle. Tide-pools are of frequent occurrence, and often of large size, and afford excellent opportunities for obtaining the shallow-water and littoral species of animals, and many beautiful algæ. One very large pool on Ram Island Ledges was especially rich, and was visited several times with profit. In this pool young lobsters of all sizes were very abundant beneath the stones. Two species of Chitonidæ also occurred here, together with many other species not usually to be found at low-water mark. Hydroids and Bryozoa, of many species, were abundant in this and other similar pools. The shore species obtained upon the islands and outer shores of the bay were nearly all boreal or arctic forms. In the harbor of Portland, on the piles of the wharves, etc., a few more southern species were met with, though the northern ones predominate even there.

Several insects were met with between tides. Among these were *Chironomus oceanicus*, and the larvæ, about two inches long, of a fly, probably an *Eristalis*, which lived in small tide-pools, under stones, and extended their long tapering tails up to the surface; the pupa of a fly allied to *Ephydra;* a species of *Bledius*, and several other beetles; and two or three species of mites, were also collected between tides. The following were among the shore-dwelling species:

Crustacea.

Cancer borealis.
C. irroratus.
Hippolyte pusiola.
H. spina.
Crangon vulgaris.
Eupagurus Bernhardus.
E. Kroyeri.
Gammarus ornatus.
Gammarus marinus.
Hyale littoralis.
Talorchestia megalophthalma Smith.
Orchestia agilis Smith.
Calliopius læviusculus.
Pontagenia inermis.
Amathella angulosa (?).
Cerapus rubricornis.
Unciola irrorata.
Jæra copiosa.
Idotea irrorata.
I. phosphorea Harger.
Erichsonia filiformis Harger.
Balanus balanoides.

Annelids.

Lepidonotus squamatus.
Harmothoë imbricata.
Eunoë Œrstedii.
Nephthys, sp.
Nereis virens.
N. pelagica.
Eulalia pistacia V.
Eteone, sp.
Phyllodoce catenula V.

Rhynchobolus dibranchiatus.	Autolytus cornutus.	Amphitrite brunnea(St.sp.).
Cirratulus cirratus.	Proceræa gracilis, new sp.†	Polycirrus, sp.
Lumbriconereis fragilis.	Polydora, sp.	Myxicola Steenstrupii.
Stephanosyllis ornata V., new sp.*	Nicomache, sp.	Fabricia Leidyi V.
	Clymenella torquata V.	Potamilla oculifera V.
	Cistenides granulatus.	Spirorbis borealis.

Turbellaria.

Nemertes viridis.	Cosmocephala Stimpsonii V.	Fovia affinis.
Borlasia, sp.	Monotus spatulicauda.	Leptoplana ellipsoides, etc.
Tetrastemma, three sp.	Monocelis, sp.	

Mollusca.

The shore Mollusca were decidedly northern, and the species were not very numerous. Among the most abundant of them are the following:

Purpura lapillus.	Littorina palliata.	Saxicava arctica.
Buccinum undatum.	Lacuna vincta.	Mya arenaria.
Ilyanassa obsoleta.	Rissoa aculeus.	Macoma fragilis.
Tritia trivittata.	Littorinella minuta St.	Turtonia minuta.
Lunatia heros.	Skenea planorbis.	Mytilus edulis.
Littorina littorea.	Acmæa testudinalis.	Modiola modiolus.
L. rudis.	Æolis papillosa.	Amarœcium glabrum.

* *Stephanosyllis ornata* V., sp. nov.

Body moderately slender, thickest near the middle, tapering slightly anteriorly, and rapidly posteriorly, the caudal portion acuminate, with two slender caudal cirri. Antennæ and tentacular-cirri long, slender, and tapering, slightly and irregularly annulated, or transversely wrinkled; median antenna longest, reaching back to about the tenth segment; lateral antennæ about equal to the upper tentacular cirrus, or reaching to about the sixth body-segment; lower cirrus about half as long; dorsal cirrus of the second segment very long and slender, equaling or exceeding the median antenna; dorsal cirri of the third segment as long as those of the first, or longer, more than twice the diameter of the body; those of the fourth segment less than half as long; those farther back unequal in length. Head rounded in front and behind, broad, the anterior pair of eyes larger and wider apart than the posterior ones; "epaulets" conspicuous, lanceolate, extending back to the fourth segment. Color, in life, pale green, especially beneath and on the sides above; back, bright orange-red, with transverse lines of green at the articulations; setigerous lobes whitish; lateral cirri pale greenish white; antennæ and tentacular-cirri pale salmon, often tipped with pink; epaulets orange, centered with green, and bordered by a line of white, and with a red line along the edge; head pale yellow; eyes black. Length, 12^{mm}; breadth, $\cdot75^{mm}$.

Casco Bay, 6 to 20 fathoms, stony; and in tide-pools at low-water. This was mentioned in No. xxvi, p. 43, as "*S. picta;*" that name is preoccupied.

† *Proceræa gracilis* V., sp. nov.

Body very slender, elongated. Head subcordate, longer than broad, rounded in front, posteriorly extending back in two short rounded lobes, not reaching beyond the buccal segment; anterior eyes considerably farther apart than the posterior ones. Antennæ and upper cirri of the first two segments very long and slender, faintly annulated; the median antenna is very much elongated, considerably longer than the lateral ones, and about equal to the dorsal cirri of the second segment; the lateral antennæ are about as long as the upper tentacular-cirri, or about five times the diameter of the body; the dorsal cirri of the third segment are about twice as long as the diameter of the body; the cirri on the succeeding segments are about half as long as the breadth of the body. Color, in life, pale greenish, with a narrow median dorsal line of dark brown, and a less distinct one on each side, at the base of the lateral appendages; eyes black. Length, about 25^{mm}; breadth, 1^{mm}, or less.

Casco Bay, 10 to 20 fathoms; and in tide-pools.

Radiata.

The most common shore species were:

Strongylocentrotus Dröbachiensis.	Campanularia flexuosa.	Sertularella rugosa.
Asterias vulgaris.	Sertularia pumila.	Clava leptostyla.
Obelia geniculata.	S. argentea.	Metridium marginatum.

Several species of sponges are also common between tides.

On the sheltered muddy bottoms, from just below low-water mark, to the depth of about two fathoms, the eel-grass, *Zostera marina*, grows in abundance. Among this many species of crustacea, worms, and mollusks find congenial abodes, and furnish abundant food for the fishes that frequent such localities. Some of these are somewhat southern in character.

Among the Crustacea from the eel-grass were: *Hippolyte Gaimardii; Crangon vulgaris; Mysis stenolepsis* Smith; *M. Americana* Smith; *Calliopius læviusculus;* a new genus with very large epimera, allied to *Metopa;* a new species of *Munna*, a genus of isopod crustacea, new to the American coast; *Idotea irrorata*, etc.

From the piles of the wharves at Portland a great variety of sponges, hydroids, bryozoa, etc., were obtained; the slender branched sponge, *Chalina oculata*, was here particularly abundant and fine; also *Metridium marginatum;* and the compound Ascidian, *Amarœcium glabrum* V., with many other northern forms. The *Limnoria lignorum* was found in abundance, destroying the piles and timbers.

Among the more interesting littoral species obtained on the shores of Casco Bay and vicinity, were *Littorina littorea* and the *Cancer borealis.* The latter is a large crab which has hitherto been very rare in all collections, and but imperfectly known; this we found in large numbers on the ledges at the northern end of Peak's Island and Pumpkin Knob, in tide-pools, or clinging to the sea-weeds in more exposed situations, but never concealed beneath the rocks with the *Cancer irroratus*, which was there abundant. The carapaces and claws of the former were also found in abundance at considerable distances from the shores, whither they had been carried by the gulls and crows. Owing to the exposed situations in which they live, they must fall an easy prey to rapacious birds. We obtained eighty-five specimens in one morning. The *Littorina littorea* occurred sparingly at various localities on the islands, but was found in great abundance at Scarboro, on the piles of a bridge, by Dr. Edw. Palmer. It has been supposed by several writers that this shell has been recently and accidentally introduced from Europe; but Dr. Dawson informs me that he collected it more than thirty years ago in the Gulf of St. Lawrence. It is abundant at Halifax, and we have other specimens from

Kennebunkport, Me., Hampton beach, N. H., and Provincetown, Mass. There is really no sufficient evidence that it was not an inhabitant of our shores before the advent of Europeans, but local in its habitats. It may have become more diffused in recent times, by commerce, or it may have been overlooked formerly by collectors.

One of the localities, most interesting zoölogically, that we visited, was a small shallow and sheltered cove, at the upper end of Quahog Bay, about thirty miles northeast from Portland. This place is well known to be inhabited by the round-clam or "Quahog" (*Venus mercenaria*), which is not found living elsewhere on the coast of Maine, so far as known to me. Indeed, this southern species is rare everywhere north of Cape Cod, on the New England coast, and is probably not to be found living north of Massachusetts Bay, except in the coves connected with Quahog Bay. It is also absent from the Bay of Fundy, but reappears in the southern and shallow parts of the Gulf of St. Lawrence. This anomalous distribution would be curious, even if it happened only in the case of this one species; but our investigation of this locality shows that there is quite a number of other southern species associated with the quahog, which have the same remarkable distribution, being absent along the rest of the northern coast of New England, and reappearing in the Gulf of St. Lawrence. There is, in fact, at this place a genuine colony of southern species, completely isolated from their co-species of the southern coast of New England, and surrounded on both sides by more northern forms. Several of these southern species, like the *Venus mercenaria, Crepidula convexa, Eurosalpinx cinerea, Eupagurus longicarpus, Epelys trilobus* Smith, *Meckelia ingens* Leidy, *Asterias arenicola*, etc., were not even met with among the islands and coves of Casco Bay; while others, such as *Ilyanassa obsoleta, Crepidula fornicata, C. plana, Limulus Polyphemus*, etc., occurred more or less frequently in the more sheltered and shallow waters of Casco Bay, though they are not found on the more exposed shores of Maine and New Hampshire, farther to the south and west, but have their true homes south of Cape Cod. Native oysters also occur, in a similar way, farther eastward than Quahog Bay, near Damariscotta, though it is not probable that they are indigenous elsewhere on the New England coast, north of Cape Cod,—as they certainly are not north of Massachusetts Bay,—yet they reappear in the Gulf of St. Lawrence, with the other southern forms.

In fact, the southern part of the Gulf of St. Lawrence, from Chaleur Bay to Prince Edward Island and Cape Breton Island, is a region of shallow water, occupied by another southern colony, but a much larger one than that of Quahog Bay, and containing, perhaps, a few southern species that do not occur in the latter locality; though owing to the fact that we could spend but a few hours at this place, our collection is doubtless quite incomplete. On the other hand, we have, with the exception of the shells, very imperfect lists of the southern species inhabiting the colony in the Gulf of St. Lawrence, so that a complete comparison cannot be made, at present, except with the shells; these agree very closely, according to the lists given by Dawson, Bell, and Whiteaves.

As the existence of these isolated southern colonies has an important bearing upon the question of former changes of climate on our coast, and as other facts, to be mentioned further on, are intimately connected with them, I give here a list of the species obtained by us, in the cove referred to, so far as they have been identified.

List of species collected at low-water in a small cove at the upper end of Quahog Bay.

Those with an asterisk prefixed are decidedly southern species, belonging properly to the region south of Cape Cod.

ARTICULATA.

Crustacea.

Cancer irroratus.
*Eupagurus longicarpus.
Crangon vulgaris.
*Mysis stenolepis *Smith.*
Gammarus ornatus.
Amphithoë, sp.
*Epelys trilobus *Smith*
Idotea irrorata.
Limnoria lignorum.
*Argulus, sp.
*Limulus Polyphemus.
Balanus balanoides.

Annelids.

Lepidonotus squamatus.
Nephthys ingens.
Nereis virens.
*Rhynchobolus dibranchiatus.
Fabricia Leidyi.
Spirorbis borealis.

Turbellaria.

*Meckelia ingens.
Nemertes viridis.
*Nemertes socialis.

MOLLUSCA.

Gastropods.

*Urosalpinx cinerea.
Purpura lapillus.
*Ilyanassa obsoleta.
Tritia trivittata.
Natica heros.
*Crepidula convexa.
*C. fornicata.
*C. plana.
Littorina rudis.
Littorina palliata.
Lacuna vincta.
Rissoa aculeus.
Acmæa testudinalis.

Lamellibranchs.

Saxicava arctica.
Mya arenaria.
*Venus mercenaria.
Macoma fragilis.
*Petricola pholadiformis.
Mytilus edulis.
*Modiola plicatula.
Anomia aculeata.

Bryozoa.

Alcyonidium hispidum.
Alcyonidium hirsutum.

RADIATA.

Echinoderms.

* Asterias arenicola.

Hydroids.

Sertularia pumila.	Obelia geniculata.	Clava leptostyla.

Polyps.

Metridium marginatum.

Although the species in this list, that are not marked as southern, have a continuous range northward to the Gulf of St. Lawrence, and many of them to the Arctic Ocean, North Pacific, and northern Europe, they all extend as far south as Long Island Sound, and several of them even to North Carolina. Most of them are, therefore, northern species having a wide distribution, and their presence in this particular locality has no special significance.

In Quahog Bay itself we found the bottom composed of soft sticky mud, and in this we dredged, in 4 to 6 fathoms, a great number of large and fine specimens of *Yoldia limatula* and *Macoma sabulosa*, with a number of other common species.

That the Quahog Bay colony has formerly, and within the human period, been more extensive than at present, is shown: 1,—by the fact that the quahogs have evidently been, at one time, more numerous and more generally diffused than now, for their shells are abundant in the mud. in places where no living ones could be found; 2,—by the occurrence of oysters, in great quantities and of large size, in the ancient Indian shell-heaps of this region, and also near Damariscotta, while at present the oysters found there are few and small; 3,—by the occurrence of the shells of the quahog, of large size, in the Indian shell-heaps on many of the islands in Casco Bay (these heaps consisting mainly of the shells of the "long clam," *Mya arenaria*, with a few bones of fishes, birds, and mammals).

That at a more remote period, the marine climate of this region was still warmer,* and the southern species were more abundant than during the period when the Indian shell-heaps were formed, is shown by the occurrence of great beds of oyster shells a few feet beneath the mud in Portland Harbor, where they are associated with quahogs and several other southern species, among which are *Callista convexa*, *Turbonilla interrupta*, and *Pecten irradians*. The latter is not known to live, at present, north of Cape Ann, on the New England coast. It is absent, apparently, from the colony in the Gulf of St. Lawrence, as well as from that of Quahog Bay. It is very rare north of Cape Cod.†

* The evidence here given is probably applicable chiefly to the temperature of the warmer months, or more properly to the reproductive season of the mollusks referred to, for the climatic distribution of most marine animals seems to depend mainly on the temperature of the season at which reproduction takes place.

† Willis includes this species in his nominal list of Nova Scotia shells, but without mentioning the special locality. It may, perhaps, occur in some of the sheltered localities near Halifax, where another southern colony exists.

The *Callista convexa* is still found sparingly in shallow, sheltered localities in Casco Bay, and rarely at Eastport, Me., but it is more common in the colony of the Gulf of St. Lawrence, and very common south of Cape Cod. But the oysters (*Ostrea Virginiana*) and "scollops" (*Pecten irradians*) had apparently become extinct in the vicinity of Portland Harbor before the period of the Indian shell-heaps, for neither of these species occur in the heaps on the adjacent islands, while the quahogs lingered on until that time, but have subsequently died out everywhere in this region, except at Quahog Bay. The oysters have survived only in the locality near Damariscotta, though far less abundant there than during the Indian period.

The beds of dead shells of oysters, *Pectens*, etc., were found in making excavations in the harbor with mud-digging machines. These beds extend up to or above low-water mark, and are of great extent. Mr. C. B. Fuller, who has made a good collection of these shells for the Portland Natural History Society, informs me that the farmers have, in some instances, found it profitable to cart away these ancient shells for fertilizing purposes. The position of these beds indicate that no important change in the relative level of the land and water can have occurred in that region since they were formed. These beds are, of course, easily distinguished from the much more ancient Post-Pliocene deposits that occur abundantly in the same region, but extend back several miles from the coast, and occur at all levels, from low-water mark to about 200 feet above high-water mark. The latter are characterized, in that region, by a more arctic assemblage of shells than that now inhabiting the adjacent waters, though most of the species still survive, in deep water, off the coast of Maine.

The facts above presented indicate: 1,—that in the Post-Pliocene and Champlain periods the coast was at a lower level, and the marine climate of Casco Bay was colder than at present, probably about like that of the present Newfoundland or Labrador coast; 2,—that at a subsequent period, when the coast had attained nearly or quite its present level, the marine temperature was considerably higher than at present; 3,—that the temperature of these waters has gradually declined, but was still somewhat higher at the period when the Indian shell-heaps were formed than at present.

That the existence and character of the southern colony in the Gulf of Saint Lawrence points to the same conclusion is sufficiently obvious. The survival of the southern species in that region is undoubtedly due to the great expanse of shallow water in that part of the gulf, which becomes well warmed up by the heat of the sun, in summer; and to the absence of tides sufficiently powerful to thoroughly mix up the very cold waters of the northern and deeper portions of the gulf with the warm waters of the southern part. Tides like those of the Bay of Fundy and coast of Maine would undoubtedly at once diminish this contrast in the temperature of the different parts of the gulf, and greatly lessen the temperature of the southern part, by reason of the far greater volume of the cold water.

The *origin* of the southern species in the gulf is a totally different matter. I can explain their presence there in no other way than to suppose that they are survivors from a time when the marine climate of the whole coast, from Cape Cod to Nova Scotia and the Bay of Fundy, was warmer than at present, and these species had a continuous range from southern New England to the Gulf of Saint Lawrence. At that time there may have been a direct shallow passage from the Bay of Fundy across to the Gulf of Saint Lawrence, for the land is there narrow and low; but of this we have no direct evidence. A *deep* channel there would act like the Straits of Belle Isle, and admit the cold arctic current to the coast of Maine; this may have been the case in Post-Pliocene times.

The causes of such changes in the temperature of the water may have been entirely local, and due to changes in the relative level of the land and water, in adjacent regions. Thus a rise of the land in the region of Saint George's Bank, to the extent of 250 feet, would produce an island quite as large as the State of Massachusetts, and would thus very materially alter the climatic conditions of the "Gulf of Maine," between it and the New England coast. And it would add a great body of land, now represented by Le Have Bank, etc., to the southern part of Nova Scotia, and thus greatly narrow the channel between those banks and St. George's, as well as make it more shallow; this would doubtless greatly modify the tides, and greatly diminish their force and height on the coasts of northern New England, and in the Bay of Fundy, for the "Gulf of Maine" would then have much resemblance to the Gulf of Saint Lawrence in form, and in the character and position of its main channel, and, therefore, its tides would also be similar; the small tides would allow greater differences between the temperatures of the shallow waters and deep waters, and would thus favor the southern species inhabiting shallow water. A rise of the land, of about the same amount, in the region of Newfoundland, would lay bare a great part of the Grand Banks, close up the Straits of Belle Isle, and more than double the size of Newfoundland, which would doubtless produce great climatic changes on the New England coast, as Professor Dana has suggested.

[To be continued.]

Erratum.—p. 134, for *Eurosalphinx* read *Urosalphinx*.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Amount of Carbonic gas in the Atmosphere.*—Truchot has recently made a series of determinations of the amount of carbonic gas in the atmosphere. His method of analysis consisted in passing a known volume of air through a graduated solution of barium hydrate, allowing the barium carbonate to deposit, and re-titring the solution. He finds: 1st, that at Clermont-Ferrand, where the experiments were made, the proportion of carbonic gas is a little greater during the night than in the daytime; a fact confirmatory of the observations of Saussure and Boussingault. 2d, that the proportion is not sensibly greater in the city than in the open country. 3d, that in the vicinity of green-leaved plants, the quantity of carbonic gas varies notably, according as the green parts are exposed to full sunlight, to diffused light or are in the shade; the amounts being 3·54, 4·15 and 6·49 parts in 10,000 of air. 4th, that the general mean is 0·814 milligram of carbonic gas to the liter of air, or 4·09 parts in 10,000; a number very near that usually received. 5th, that the proportion of carbonic gas diminishes with the altitude, thus:

Station.	Altitude.	Wt. CO_2 to the liter.	Vols. of CO_2 in 10,000 of air.
Clermont-Ferrand,	395^m	0·623^{mg}	3·13
Puy-de-Dôme,	1446	0·405	2·03
Pic-de-Sancy,	1881	0·342	1·72

—*C. R.*, lxxvii, 675. *Bull. Soc. Ch.*, II, xx, 494, Dec., 1873. G. F. B.

2. *On Hydrogen Arsenide.*—Janowsky has made some experiments upon the decomposition of hydrogen arsenide. He prepared the gas from sodium arsenide by the action of water, or preferably of very dilute acids; the sodium arsenide itself being prepared by heating sodium in hydrogen arsenide obtained from arseniferous zinc. When passed through phosphorous chloride in the cold, a red-brown powder of arsenous phosphide is thrown down, formed as follows:

$$PCl_3+AsH_3=(HCl)_3+PAs.$$

This substance, separated from the liquid and dried in a current of carbonic gas at 70° to 80° C., is a dark red-brown lusterless powder, containing 70·53 per cent of arsenic and 29·11 per cent of phosphorus. Water decomposes it, yielding a substance having the formula $As_3P_2O_2$. It is insoluble in alcohol, ether and chloroform, and in sulphuric and hydrochloric acids. CS_2 dissolves it in small quantity. By nitric acid, it is oxidized to arsenic and phosphoric acids. Alkali-hydrates decompose it, producing hydrogen phosphide and arsenide, arsenite and phosphite and metallic arsenic. It burns in the air, yielding phosphoric and arsenic acids. In close vessels, it decomposes on heating, into phosphorus and arsenic, which sublime. The author also observes that hydrogen arsenide is decomposed both by concentrated sulphuric and hydrochloric acids, depositing, not a solid hydrogen arsenide, but arsenic itself, and evolving in the case of the former, sulphurous acid. In contact with arsenous chloride, hydrogen arsenide is decomposed, yielding metallic arsenic and hydrochloric acid, thus:

$$AsCl_3 + AsH_3 = (HCl)_3 + AsAs.$$

Hence the author's inference, that the attraction of the two arsenic atoms for each other is greater than their attraction for the chlorine and hydrogen atoms respectively. Finally, on treating sodium arsenide with water, gaseous hydrogen arsenide is abundantly evolved, and a brown velvet-like residue is left, which gave on analysis the formula AsH.—*Ber. Berl. Chem. Ges.*, vi, 216, 1873. G. F. B.

3. *On the Sensitiveness of silver bromide to the so-called Chemically Inactive rays.*—It is well known that with ordinary silver plates the chemically active portion of light is the violet or ultra-violet. Tested in the spectrum, this portion extends only as far as the line E in the green. VOGEL has now discovered the remarkable fact that by suitable treatment, silver plates may be rendered sensitive to any of the rays of the spectrum at pleasure, even to the red. His attention was called to this subject by observing that some dry plates, prepared with silver bromide, received from Wortley in England, were more sensitive to the green rays, near the line E, than to the bright blue, near the line F. This led to an investigation into the sensitiveness of silver bromide to the various colors of the spectrum. This spectrum was produced by a direct-vision prism, receiving its light from a slit $0{\cdot}25^{mm}$ wide, illuminated with sunlight from a Foucault's heliostat. The image was produced by a Steinheil's camera lens, the portion of the spectrum from D to G being 35^{mm} in length. The experiments were all made from 11 to 2 o'clock in the day and during a cloudless sky. The time of exposure was generally ten minutes, and the plates were developed with solution of ferrous sulphate. It was at once observed that the bromide was sensitive to rays beyond the line F, rather than short of it, as had been supposed. Moreover, while wet plates, with an acid developer, were found to be sensitive to rays extending nearly to the yellow (to between D and E), dry plates were affected by rays two millimeters beyond D; i. e., rays in the orange. In the former case, the most intense action took place between G and F; diminishing rapidly beyond F toward E. In the latter, though the action in the blue was much weaker, its decrease was much less rapid. The author concludes from this that dry silver bromide is the more delicate for the less refrangible, wet silver bromide the more delicate for the more refrangible rays. In all the dry plates prepared by him, however, no such increase of sensitiveness from the blue toward the green was shown as was exhibited by the English dry plates above mentioned. In casting about for a reason for this, the common explanation of the use of a silver solution as a sensitizer,

i. e., that since the action takes place principally in the blue, this solution acts by absorbing the blue rays—occurred to him, and he concluded that the English plates must contain some substance which absorbed green light more strongly than blue. Upon examination, the Wortley plates were found to contain uranium nitrate, gum, gallic acid, and a yellow coloring matter as a protective. Upon removing this yellow coating the plates were found to be no longer sensitive to the green rays. Vogel now directed his experiments to obtain a material with which to impregnate the silver bromide, which, while uniting, like the silver solution, with the iodine or bromine set free in the action, should at the same time absorb strongly the yellow rays and thereby increase the sensitiveness of the silver bromide for yellow. Such a substance he found in corallin, the solution of which showed a strong band at D in its absorption spectrum, while at the same time, it transmitted considerable blue light. Dissolving the corallin in alcohol, he added it to his collodion until it was colored strongly red. Plates prepared with this collodion were found to be sensitive to the indigo rays; but the sensitiveness decreased toward the blue, was weak at F, and increased again in the green, becoming *in the yellow almost as great as in the indigo!* In corallin therefore we have a substance by means of which a color, yellow, hitherto considered chemically inactive, may be made as effective photographically as the indigo itself. Extending his investigations, Vogel observed that the green aniline colors, which absorb the red rays between D and C, render sensitive a silver bromide-collodion, even to the red rays. The sensitiveness decreases from the indigo to the yellow, then increases again, attaining its maximum at the precise point where the absorption band is situated. The author believes therefore that bromide of silver may be made sensitive to any color at will and suggests that it may be as possible to photograph the ultra-red as the ultra-violet spectrum. At all events, he photographed a blue band on a yellow ground, obtaining in the picture a dark band on a light ground. Sensitiveness to light in a plate is dependent, consequently, not only upon the absorptive power of the silver salt itself, but also upon that of the substances with which it may be mixed.—*Ber. Berl. Chem. Ges.*, vi, 1302, Nov., 1873. G. F. B.

4. *On the Existence of Chromium dioxide.*—HINTZ has investigated, in the laboratory of Dr. Lothar Meyer, the methods of preparation and properties of chromium dioxide. He used: (1) Vauquelin and Brandenburg's method, decomposing chromic nitrate by heat. The result contained too little oxygen. (2) Kopp's method, by the action of chromic acid on chromic hydrate. (3) Döbereiner's, by heating chromic acid; the product was not uniform. (4) By heating chromic hydrate with free access of air. Result unsatisfactory. (5) Schweitzer's method, by passing nitrogen dioxide gas into a moderately dilute solution of potassium dichromate; product was a brown hydrate. (6) Schiff's method, by the action of chloride of lime on chromic hydrate; no result.

The product by Schweitzer's method—the fifth above given—when dried at 250° till the weight is constant, approaches very near to the composition of chromium dioxide. It is a fine deep black very hygroscopic powder, forming a dark red-brown hydrate. Chlorine has scarcely any action upon it even at 250°. Hydrogen chloride gas acts only very slightly, evolving water and chlorine and forming the violet chloride. Black chromium dioxide is therefore an extraordinarily indifferent body, essentially different in this respect from molybdic oxide. This suggests that instead of being a simple oxide CrO_2, it may belong to the so-called saline oxides, Cr_2O_3,CrO_3.—*Ann. Chem. Pharm.*, clxix, 367, Oct., 1873. G. F. B.

5. M. STEFAN has conducted a series of *experiments on the evaporation of volatile liquids, especially ether.* Such experiments have hitherto led to no results expressible in the form of laws. The conditions under which they were made were not simple enough; yet they were sufficiently varied. The science of evaporation, especially of the diffusion of vapors, remained an unoccupied field.

In the following experiments, to avoid the great lowering of the temperature at the surface, narrow tubes were chosen for evaporating vessels, instead of the wide vessels hitherto used.

(1.) The velocity of the evaporation of a liquid from a tube is inversely proportional to the distance of the level of the liquid from the open end of the tube. This law holds with rigorous exactness when the distance of the level a little exceeds 10^{mm}.

(2.) The velocity of the evaporation is independent of the diameter of the tube. This result was obtained from experiments with tubes the diameter of which varied from $0{\cdot}3^{mm}$ to 8^{mm}.

(3.) The velocity of the evaporation increases with the temperature, so far as with this the vapor-pressure of the liquid rises. If p be the maximum of elasticity of the vapor corresponding to the temperature of the observation, P the atmospheric pressure under which the liquid evaporates, the velocity of the evaporation is proportional to the logarithm of a fraction of which P is the numerator and $P-p$ the denominator. If the pressure of the vapor becomes equal to that of the air, this logarithm becomes infinitely great, and signifies that under this condition the liquid boils.

Experiments were also made on evaporation in closed tubes.

If the open end of a tube, the other end of which is closed, be dipped in ether, bubbles form and issue continually from the tube, and at first the times in which successively equal numbers of bubbles form, are proportional to the odd numbers.

If the immersed tube contains hydrogen instead of air, the same number of bubbles form in one-fourth of the time. Evaporation proceeds in hydrogen, therefore, four times as rapidly as in air.

The same result was also furnished by an experiment in which a liquid can be evaporated in an open tube in various gases. It consists of a T-shaped glass tube, through the horizontal cross-piece of which a continual current of the gas is conducted, while the liquid to be evaporated enters the vertical arm.

If a tube provided with a cock be dipped with the cock open in ether, the level of the liquid within the tube will sink below that outside; and at first the depths to which the interior level sinks below the exterior in definite times are as the square roots of those times.—*Philos. Mag.*, xlvi, 483. E. C. P.

6. Prof. VILLARI has *measured the time required by flint glass to change its magnetic condition, or to rotate the plane of polarization.* A beam of polarized light was passed through the poles of a powerful electro-magnet and a glass cylinder interposed, which acted like a cylindrical lens. This cylinder could then be turned end over end with any desired velocity. When not magnetized, it of course produced no effect on the plane of polarization whether in motion or not. But when caused to revolve rapidly, the angle through which it turned the plane of polarization was considerably diminished, since in each revolution it remained in the axial direction too short a time to acquire its full magnetic polarity. To impart sufficient diamagnetic intensity to be perceptible by the change of plane, at least ·0012″ was required; while to produce the complete effect, 0024″ was necessary.—*Pogg. Annalen*, No. 7, 1873. E. C. P.

7. M. E. DUCHEMER addresses a note to the French Academy, in which he claims that *a circular compass needle possesses the following advantages* over the usual form:

1st. A magnetic power, for a given diameter, double that of a needle whose length is equal to this diameter.

2d. The existence of two neutral points instead of one, which has the effect of maintaining the position of the two poles constant; the magnetism seems to be so energetically preserved, that even the strongest sparks of a Holtz machine do not cause any displacement of the poles of the magnet.

3d. A more satisfactory means of suspending the magnet when it is well mounted and balanced by a plate of agate; it seems then to move as if placed in a liquid.

4th. An increase in sensibility of the magnet proportional to its diameter.

5th. The possibility of neutralizing the magnetism of the vessel by means of a second magnetic circle, changing the position by an amount calculated beforehand, and thus permitting the compensation of the compass before the sailing of the vessel. This idea was suggested by Capt. D. Venie.—*Comptes Rendus*, lxxvii, 890. E. C. P.

8. Dr. J. B. SANDERSON presented a note to the Royal Society *on the electrical phenomena which accompany irritation of the leaf of Dionæa muscipula.*

When the opposite ends of the living leaf of this plant are placed as non-polarizable electrodes and connected with the terminals of a Thomson's galvanometer, a deflection is produced which indicates a current from the proximal to the distal end of the leaf. This current he calls the *normal leaf-current.* If, instead, the leaf stalk is placed on the electrodes (the leaf remaining united to it) in such a way that the extreme end of the stalk rests on one electrode, and a part of the stalk at a certain distance from the leaf on the other, a current, called a *stalk-current*, is indicated, opposed to that in the leaf. To show these currents, it is not necessary to expose any cut surface to the electrodes.

In a leaf with the petiole attached, the strength of the current increases as the length of the petiole diminishes. Thus, a leaf with a petiole an inch long gave a deflection of 40 divisions, and by successively reducing its length one-half, this deflection was increased to 50, 65, 90 and 120. Partially severing the leaf gave the same result as if it was completely cut off.

If the leaf is placed on the electrodes as before, on introducing the petiole into the circuit of a small Daniell, the deflection is increased when the current passes down the petiole, that is, from the leaf. On reversing the current the deflection is diminished.

If, the leaf being so placed that the normal leaf-current is indicated by a deflection to the left, a fly is allowed to creep into it, it is observed that the moment the fly reaches the interior (so as to touch the sensitive hairs on the upper surface of the lamina) the needle swings to the right, the leaf at the same time closing on the fly.

The fly having been caught does not remain quiet, and each time it moves, the needle again swings to the right, always coming to rest in a position somewhat farther to the left than before, and then slowly resuming its previous position.

The same effects are observed in touching the sensitive parts of the still open leaf with a camel's-hair pencil, or pinching the closed leaf with a pair of forceps.

Placing the leaf-stalk and leaf on the electrodes as before, the stalk current is seen to be increased, whenever the leaf is irritated as above.

If the open leaf having been placed on the electrodes, one of the concave surfaces is pierced with a pair of platinum needles connected with the secondary coil of a Dubois Raymond induction apparatus, it is observed that when the circuit is closed the needle swings to the right, as when irritated mechanically. No difference is observed when the induced current is reversed. The observation may be repeated any number of times, but no effect is produced unless an interval of from ten to twenty seconds has elapsed since the preceding irritation.

If the part of the concave surface of the leaf nearest the petiole is excited, the swing to the right is always preceded by a momentary jerk of the needle to the left. This effect cannot be produced by irritating any other part of the concave surface of the leaf.

An interval of from a quarter to a third of a second always intervenes between the act of irritation and the negative variation.—*Nature*, ix, 75. E. C. P.

II. Geology and Natural History.

1. *Volcanic Energy: an attempt to develop its true Origin and Cosmical Relations;* by Robert Mallet, A.M. F.R.S., etc.—This important paper is now published in full in the Journal of the Royal Society, having been read in abstract June 20, 1872.

The author accepts in general Sir W. Thomson's view, that plutonic action or "Vulcanicity" results from the dissipation of energy in the shape of terrestrial heat. Setting aside as untenable, upon the basis of observed facts, all other hypotheses, he develops the idea first distinctly expressed by Constant Prevost, that elevation, folding and crushing of strata is the result of tangential pressure, originating in the contraction of the earth's crust by secular refrigeration; considering the latter, as well as the general increase of temperature, with depth, as facts sufficiently established.

Assuming that in consequence of the viscosity of the cooling materials, the temperature would, after a certain epoch, always have been highest near the center of the mass; and that a crust began to form at the poles, advancing in hemispherical sheets toward the equator, he argues that tangential pressures caused in the thin, hot crust by contraction, would *first* be met by the formation of wrinkles; the crust, even if dislocated, remaining at the surface by virtue of the thick viscous *couche* beneath, and not sinking into the latter, still less to the hot central portion. After the crust had thickened still further, the rapid contraction may reasonably be conjectured to have resulted in the rough outlining of our present seas and continents, by deformation. The sudden contrary flexures at the junctions of the continents and sea-basins initiated lines of weakness in the early crust. During a third period, the crust becoming still thicker and more indurated, and the viscous bed beneath greatly thickened, so as to cut off convection; the former became capable of transmitting tangential stresses within itself, and began to corrugate and double upon itself, elevating mountain chains along the lines of weakness, and extruding rocks, now forming dykes and intrusions. Lastly, during a fourth period, of a greatly thickened and stiffened crust, and slow rate of cooling, began that balance and play of forces, the effects of which are now recognized as volcanic.

Vulcanicity may, according to the author's view, be thus defined: "The heat from which terrestrial volcanic energy is at present derived is produced locally within the solid shell of our globe, by transformation of the mechanical work of pressure, or of crushing of portions of that shell; which compressions and crushings are produced by the more rapid contraction, by cooling, of the hotter material of the nucleus beneath that shell, and the consequent more or less free descent of the shell by gravitation; the vertical work of which is resolved into tangential pressures, and motion, within the thickness of that shell."

As regards the modus operandi of this agency, Mallet considers mainly three points, viz: 1. Evolution of heat by compression of rocks within the limits of elasticity; 2. Friction, by sliding of beds, or planes of fracture upon each other; 3. Rock crushing. These, acting severally or jointly, and more or less localized both vertically and horizontally, are adequate to explain, not only the irregularities observed in the increase of temperature, but when acting in the presence of water, constitute also an adequate cause of vulcanicity. "To prove this it is necessary to show, 1st. That the gravitation of the unsupported shell is adequate to crush into powder all the materials of which it consists, no matter how thick the shell may be, unless equal to the radius; 2d. What is the total amount of contraction of materials analogous to the rocks of the solid shell, between the temperature of fusion (or one above it) and that of our atmosphere now; 3d. What is the mean work per unit of weight and volume necessarily expended in crushing to powder the rocks of which the solid shell consists, and what is the amount of heat due to the transformation of such work."

Concerning the first point, Mallet deduces from known data and assumed conditions largely within the limits of probable maxima, that in an unsupported shell, the crushing force by horizontal thrust would exceed at least 428 times that required for crushing (a free cube of) the hardest known rocks; and that no practically possible conditions will suffice to prevent crushing under such pressures. He then proceeds to investigate experimentally the question as to the amount of heat produced by rock-crushing, and whether that amount be sufficient to account for existing volcanic phenomena. Having tested by preliminary experiments the correctness of Hirn's statement, that in crushing very inelastic bodies, the heat evolved is almost precisely the equivalent of the work expended in deformation, he crushes a series of cubes (1½ inch square) of different rocks, from soft oölite through limestones and sandstones to granite and porphyry, in the testing machine (designed by Ramsbottom) of the Reeve Locomotive Works; every precaution being taken to insure accuracy. The pressures at which disintegration commenced, and those at which the final crush-down to powder occurred, were noted, as well as the distance through which the crushing plunger had descended at either point. The elevation of temperature by crushing was in all cases very perceptible, and in those of the harder rocks very considerable. It was not directly determined, but calculated by the aid of Joule's equivalent number, and the (known or re-determined) specific heats and gravities of the rocks.

From the elaborate table in which these results are given and discussed, it appears that the mean work expended in crushing one cubic foot of the rocks experimented upon, varied from 255,951·39 footpounds for oölite, to 5,653,722 in gray Guernsey granite, the corresponding increase of temperature being respectively 8·004° and 217·24° F. Upon the basis of his experiments, and of general considerations, he obtains for the "mean rock" of the first 100 miles of crust, the following data:

British heat-units per cub. foot of rock crushed, ... = 6472
Temperature Fahr. to which it is raised, ... = 183·74
Cub. foot of rock at 300° F., fusible at 3,000° by crushing 1 cub. foot of mean rock, ... = 0·108

the liquefaction of one cubic foot of ice at 32° being equivalent to the crushing work of 1·277 cubic foot of mean rock.

Passing to the question of the total contraction of fused mineral masses, Mallet shows the unreliability of the experiments heretofore made on the subject by Bischof, Forbes and others. His own experiments were made by casting iron-furnace slag, very similar in composition to basalts, in very large and thick hollow iron cones, open at both ends, but placed upon iron bed plates. The cones were seen full of liquid slag of about 3680° F., and its volume accurately measured at the moment when a self-supporting crust had formed all around, at a temperature of about 3,000°. The slag cones were again measured, after cooling, at 53° F.; and the results deduced, with many precautions and corrections, are these:

Mean coëfficient of contraction from fluidity to solidification,
3680° to 3000° F. = 0·982·0
3680° to 53° 0·932·76

which is about 6 per cent, against 20–25, as determined by Bischof.

The earth's diameter being at present 7,916 miles, it must have been when liquid = 8,105 miles, having shrunk by 189 miles at least. This represents more than the work of a shell of 94½ miles thick, falling through 47 miles.

As for the present rate of cooling, whichever of the coëfficients usually given we adopt, the annual loss cannot be less than 575 to 777 cubic miles of ice melted to water at 32°. If the total amount annually lost were produced by rock-crushing, it would take 987 cubic miles of crushed rock. But doubtless by far the greater part reaches the surface from a cooling nucleus, and but a small portion is manifested as vulcanicity. Upon an estimate of the entire mass of volcanic cones known, Mallet comes to the conclusion that 7,200 cubic miles of crushed rock would have sufficed (thermally) to produce them; which amount represents the loss of heat for eight years only, whereas the actual period of time elapsed during their production is immense.

Having proved that the crushing of the earth's solid crust affords a supply of energy sufficient to account for terrestrial vulcanicity, and that the necessary amount of crushing falls within the limits that may be admitted as due to terrestrial contraction by secular refrigeration, Mallet proceeds to discuss the potent reasons leading to the assumption of a thick crust, and the inadmissibility of either supposing water to reach the liquid nucleus from the surface, or that the fused materials of that nucleus could be forced up through such enormous distances. The yielding of the crust to contraction will naturally be, not continuous, but *per* *saltum*, and more or less localized along lines of especial weakness, at points constantly displaced by these very acts. The effects are therefore irregularly intermittent, and non-periodic; as are volcanic eruptions and earthquakes. The linear arrangement of volcanoes, and their general parallelism to great mountain chains, thus also finds its natural explanation. The volcano is a safety valve for the earthquake, in so far as its activity prevents the accumulation of virtual energy, to the extent that on sudden yielding, widely destructive cataclysms would ensue.

A parallel train of reasoning applied to the moon at once explains its apparent present condition. If vulcanicity be dependent upon secular cooling, then the smaller the planet, the more intense should be volcanic energy, and the briefer its duration.

If, then, the cause assigned is adequate, and all parts of the theory fit together with the facts, the author submits that the theory may be regarded as a true interpretation of Nature.

E. W. H.

2. *Geology of the Cobequid Mountains, Nova Scotia;* by D. Honeyman. (From the Proceedings of the Nova Scotia Institute of Natural Science.)—The railway opens up in a beautiful manner the geological structure of the Cobequid mountains. The most instructive part of the section is that which traverses the mountains on the Cumberland side of the county line. The central or syenitic formation extends along the line of railway a distance of 24,000 feet; of this 12,900 feet is in the county of Cumberland. On either side of this is the Lower Silurian. On the Colchester side this formation has its largest development, having a width of 10,400 feet. On the Cumberland side the width is 8,800 feet. This is a fact of possible economic importance. It is a great metalliferous, as well as marble-containing series. This is the first time that this formation has been distinctly recognized in these mountains. On the Cumberland side this formation has, in its lower part, diorites and diorite porphyries, and a considerable number of other porphyries, jasper rocks, conglomerate, jaspideous and amygdaloidal. The last correspond exactly with the Quebec conglomerates of Canada, which are copper-producing. Above the conglomerates is a considerable thickness of diorites, shales and slates, which are regularly interstratified. The shales contain abundance of fossils of older forms than any yet found in Nova Scotia. These are in the finest state of preservation. *Graptolites* of the most delicate and beautiful forms are in a state of preservation unexampled in such rocks. *Trilobites* and *Lingulæ* of forms strange to Nova Scotian geology are also found. These are of *Hudson River* age, the upper part of the Lower Silurian.

This important discovery, made by the author on the 17th of September, has solved a very important problem regarding the age and succession of the older metamorphic rocks of Nova Scotia and Cape Breton, and possibly also of New Brunswick. The vertical thickness of the fossiliferous and interbedded diorites is 770 feet. Succeeding the Lower Silurian on the Colchester side is a band of Middle and Upper Silurian, about 2,000 feet wide. This is the band which contains the Londonderry iron deposits. Here they are not apparent. On the Cumberland side the corresponding Middle Silurian band has a width of 3,000 feet. One fossil, a *Lingula*, was found in the lower part.

Succeeding the Middle Silurian, on the Colchester side, is a great width of the Carboniferous formation. This shows neither limestone, gypsum nor coal.

On the Cumberland side is the Carboniferous formation, which contains its coal fields. The part of this formation which immediately lies upon the metamorphic formations of the Cobequids consists of conglomerates and sandstones. One remarkable feature of these two was that they contained embedded blocks of syenite of 200 pounds and upward at a distance of 2¼ miles from the original rock of the mountain. Fossil plants embedded in the sandstone with these rocks are found closely adhering to the latter.

In Mr. Amos Purdy's Freestone quarry, at Wentworth, in connection with these conglomerates and sandstones, sandstones were found having abundance of rain prints, rill marks, fossil plants and abundance of footprints of small and large reptiles. One reptile had trodden on a fern leaf which lay in the rain-pitted mud, and another had dragged its tail in its slow march.

Succeeding the Carboniferous on the Colchester side is the Triassic, or New Red Sandstone. This extends to Truro on the line of railway. On the Cumberland side it is absent.

3. *On a shale (Brandschiefer) in the Lower Permian near Pillnitz in Saxony;* by Eugene Geinitz.—This shale, according to Mr. Geinitz, has afforded remains of the fish, *Acanthodes gracilis* Beyrich; wings of *Blattina Weissigensis* E. Geinitz, and another near *B. acanthophila* Germar; *Gyromices Ammonis* Göpp. (the little Serpula of the Coal measures, made a fungus by Göppert; besides species of *Calamites, Asterophyllites, Annularia, Schizopteris, Sphenopteris, Hymenophyllites, Odontopteris. Callipteris, Neuropteris, Dictyopteris, Cyatheites, Alethopteris, Walchia, Cardiocarpus, Sigillariostrobus*, and the Cycads *Pterophyllum Cottæanum* Gutbier, *Pt. blechnoides* Sandb.; also *Cordaites Ottonis* Gein., *C. principalis* Germar, *C. Roesslerianus* Gein., *Pinites Naumanni* Gutb., *Schützia anomala* Gein. A plate representing the wings of *Blattinæ*, the fruit *Sigillariostrobus, Sphenopteris Naumanni*, and two species of *Pterophyllum*, accompanies the paper. The association of Triassic-like Cycads with Carboniferous plants—a fact pointed out before by Sandberger, and also by Prof. Geinitz for a Siberian locality—is a fact of great interest.

4. *Asmanite, a new species of Silica from a Meteorite;* by Maskelyne.—Maskelyne found this mineral in the meteorite of Breitenbach, in which it occurs in colorless grains, 1 to 3 millimeters in diameter, along with nickeliferous iron, bronzite, chromite and troilite. It has the form of a right rhombic prism (I)

of 120° 20′, with the planes i-$\check{i}$, 1-$\check{i}$, $\frac{1}{2}$-$\check{i}$, $\frac{1}{3}$-$\check{i}$; and also rounded octahedral planes. The inclination of 1-$\check{i}$ on the base is 117° 46′. Cleavage is distinct parallel to the base, and imperfect in the direction of the vertical prism I. Maskelyne also observed that the crystals are optically biaxial. Hardness between that of apatite and feldspar, or 5·5. Specific gravity 2·245, that of tridymite (another form of silica) being 2·3, and of quartz 2·6. An analysis afforded Maskelyne—SiO^2 97·430, Fe^2O^3 1·124, CaO 0·578, MgO 1·509 = 100·641. It is about as insoluble in a solution of carbonate of soda as quartz.

Vom Rath has examined the mineral and confirms the results of Maskelyne. He obtained for the specified gravity 2·247; and for the composition SiO^2 96·3, FeO 1·6, MgO 1·1=99·0. The presence of iron and magnesia is attributed to the presence of a little bronzite. The grains of asmanite may be separated from the rest by treatment with dilute chlorhydric acid. It is suggested by Maskelyne that quartz found by Partsch in the meteorite of Steinbach (which closely resembles that of Breitenbach) may have been asmanite.

5. *Mineralogische Beobachtungen V;* von Dr. ALBRECHT SCHRAUF. 88 pp. 8vo. (From the 67th volume of the Sitzb. of the k. k. Akad. der Wissensch. 1873. Wien.)—This memoir by the eminent crystallographer of Vienna, is an elaborate treatise on the mineral species of the Brochantite group. It gives a full exposition of the crystallization of the species, and of their chemical and physical relations.

6. *Geognostisch-mineralogische Fragmente aus Italien;* von Prof. G. vom RATH, of Bonn. Part IV, with two plates. (From the Zeitschr. of the Deutschen Geol. Gesellschaft, 1873.)—This 4th part of vom Rath's learned memoir consists of geographical, geological and mineralogical observations on the vicinity of Massa Maritima; on Calabria; and on Vesuvius. Under the last head, vom Rath has many important observations on the minerals formed at the eruption of 1872. He shows that the composition of *Microsommite* of Scacchi is related to that of the sodalite group, obtaining in his analysis,

$\ddot{\bar{S}}i$ 33·0, $\ddot{\bar{A}}l$ 29·0, $\dot{C}a$ 11·2, $\dot{K}$ 11·5, $\dot{N}a$ 8·7, Cl 9·1, $\dddot{S}$ 1·7=104·2;

and makes the important observation that nephelite, sodalite and microsommite, which are alike in occurring in the pores of lavas, have resulted alike from the action of sea water (rich in chloride of sodium) on the silicate of the lava. Microsommite occurs in hexagonal prisms, with pyramidal planes on the basal edges, and has 43° 40′ as the basal angle of the pyramid. Vom Rath concludes also that leucite was one of the results of sublimation at the eruption of 1872, as well as augite, hornblende, cavolinite, biotite, hematite and magnetite.

Vom Rath's paper on the crystallization of leucite, pointing out that it is tetragonal, is contained in Poggendorff's Annalen Erganzungsband, vol. vi; and the same paper treats of the crystalline forms of the Vesuvian augite and hornblende derived from sublimation, the forms of the crystals of sulphur; Arcanite of Roccalmuto; also of Jordanite from Binnenthal, mica of Vesuvius; epidote of Vesuvius; microsommite; and chalcomorphite, a new species from the lava of Niedermendig of the hexagonal system.

7. *Note on Anomphalus Meeki.*—Prof. F. B. Meek has called my attention to the figures of *Anomphalus rotulus*, the type of the genus, on plate XXIX of the recently-issued fifth volume of the Geology of Illinois. From these, it is evident that my species, *A. Meeki* (this Journal, August, 1872, p. 88), is not congeneric with *A. rotulus.* As I have been unable to learn of any genus to which it can properly be referred, I am obliged to consider it as the type of a new genus, for which I propose the name *Dawsonella*, in honor of the scientist who has done most to bring to our knowledge the land-snails of the Carboniferous. The most prominent characteristic of the type is the thin plate attached to the columella, and covering half or more than half of the aperture of the shell. In form, this reminds one of the similar plate in *Navicella*, with which genus, however, the shell has no apparent affinities. I see no reason to change my reference of this type to the *Helicidæ;* though the true *Anomphalus* probably belongs to the *Rotellidæ*, as stated by its authors. F. H. Bradley.

New Haven, Ct., Jan. 20th, 1874.

8. *Glacial Period in New Zealand.*—Dr. Hector has shown that the Glacial period was a marked one in New Zealand geological history, and holds that the era was one of "prolonged though perhaps not excessive elevation"; and that "in consequence, especially in the South Island, there is a marked absence of marine drifts and tills."—*Nature*, Jan. 1.

9. *Fossils of New Zealand.*—Catalogues of fossils from the Tertiary formations, and also an illustrated work on the fossil plants from the different coal-bearing formations, are nearly ready for publication. Seven species of *Plesiosaurus* and related genera have been obtained at the Amuri Bluff (Marlborough) and at the Waipara.—*Ibid.*

10. *Addendum to Article XLVII*, vol. vi; by the author, T. B. Comstock.—Concerning the age of the Bridger and Green River groups, referred to the Miocene by Hayden, there is still much dispute, one of the best authorities expressing confidently the opinion that they must be considered Eocene.* In this paper I have followed Hayden's classification provisionally only. For the present I prefer to express no decided opinion.

I am indebted to Dr. J. S. Newberry for a review of my Silurian fossils from the Wind River Mts., resulting in the discovery that this formation is there made up of rocks of the Quebec group of the Calciferous epoch overlaid by a considerable thickness of the Niagara limestone.

The Niagara limestone and the Oriskany sandstone are new formations to this region.

Cleveland, O., January 1, 1874.

* Prof. O. C. Marsh writes me that he has obtained abundant evidence of the Eocene age of these beds.

11. *Stibioferrite from Santa Clara Co., California;* by E. GOLDSMITH.—This antimonial mineral occurs on stibnite, constituting layers from a thin coating to a quarter of an inch in thickness, and sometimes crystallized in cavities. The crystals were orthorhombic, and are rhombic prisms of 110° 8′, with the vertical edges truncated. It is opaque when amorphous, but subtranslucent when crystallized; the luster resinous, of a faint yellow color, with the streak dull yellow to straw-yellow. Hardness =4. G.= 3·518. B.B., in the closed tube yields water and a white sublimate; on charcoal, metallic globules and a white incrustation, with fumes on stopping the heat; insoluble in nitric acid; soluble in hydrochloric. An analysis afforded, after deducting 8·84 of quartz, Sb^2O^3 47·69, Fe^2O^3 35·36, H^2O 16·94 = 100; affording the oxygen ratio for the antimony, iron and water 1·1 : 1 : 1·4; taking it at 1 : 1 : 1·5, it corresponds to 2 of sesquioxides of antimony and iron to 3 of water.—*Proc. Acad. Nat. Sci. Philad.*, p. 366, 1873.

12. *Chromite and Trautwinite from Monterey Co., California;* by E. GOLDSMITH. Proc. Acad Nat. Sci. Philad., 1873, p. 365.—Analyses afforded

	Si	Cr	Fe	Al	Ca	Mg		
Chromite,	12·12	52·12	15.24	2·18	5·65	12·29	sp. gr.	4·1647
Trautwinite,	21·78	38·39	13·29	0·81	18·58	7·88	"	3·505

Mr. Goldsmith concludes that the trautwinite is a result of the alteration of chromite; and that the silica and lime found in this chromite is in the state of trautwinite. The mineral is not acted on by hydrochloric acid.

13. *Dr. Regel on Vitis*, a Monograph recently published in the Annals of the St. Petersburgh Botanic Garden, we commend to the notice of Dr. Engelmann, as being most familiar with the botany of our North American Vines and their near relatives. One need not know them profoundly, however, to be able to appreciate the soundness of the judgment that combines under one species, *V. cordifolia* (our Frost Grape) with *V. vulpina*, the Muscadine or Southern Fox Grape!

The Gardener's Chronicle calls attention to Dr. Regel's bringing forward as an "objection to the Darwinian theory, the circumstance that the cultivation of the American vines has resulted, in the course of a few score of years, in the production of as great an amount of variation as has been obtained in Enrope and Asia during tens of centuries." Upon which it may be remarked, 1, that there are in North America several species to work with, against the single one cultivated in Europe and western Asia; and, 2, that the American varieties in question for the most part have not been made, but rather selected and improved within the last two or three score years. As most youngsters here very well know, all our Vines vary greatly as to their fruit in the wild state. So that nature had long ago begun the work which the cultivator in this case only accelerates, and directs, and gets the credit for.

A. G.

14. *Hepaticæ Boreali-Americanæ;* by Coe F. Austin. Closter, New Jersey, 1873.—This classical collection, which is very important for those who undertake to collect and study our *Hepaticæ*, was announced, if we mistake not, some time ago. The sets are now issued, with tickets, index, and title-page, making a choice collection of 150 species. The tickets are in English, except the characters of new species, which are in Latin. The number of sets is limited; the price $15, but soon to be raised. A separate pamphlet is issued, of 48 pages, octavo, containing the tickets, index, &c., of the collection. Following the orthography of Jungermann's name, the familiar genus dedicated to him is *Jungermannia*, which Mr. Austin has shortened to *Jungermania*. A. G.

15. *Ilysanthes gratioloides*, a rather insignificant plant of our flora, has recently been found in abundance in France, in the neighborhood of Nantes. It is thought to have appeared there between the years 1853 and 1858, and to have been in some way received from the United States, but the manner of its coming eludes enquiry. An account of it is given in Bull. Bot. Soc. France, session of Nov. 15, 1872. A. G.

16. *Synopsis Generis Lespedezæ, auctore* C. I. Maximowicz.—This fills sixty pages of the Annals of the St. Petersburgh Botanic Garden, and was presented at its semi-centennial celebration on the 22d of March last. The genus is one of those mainly divided between the eastern United States and eastern Asia, chiefly Japan and China, and so comes especially before Dr. Maximowicz, who is working up the Flora of Japan. We found our own species difficult when we studied them more than thirty years ago; we welcome the light which a new study of the whole genus is likely to throw upon them, and are quite prepared to accept, after verification (upon the first convenient opportunity), the moderate changes which Dr. Maximowicz concludes to make. We trust, and indeed should expect, that his characters may serve to distinguish from *L. violacea* the *L. reticulata*, including *L. sessiliflora* and our variety *angustifolia*; the junction of *L. procumbens* with *L. repens* confirms a view which some of our American botanists had already insisted on; and, as to the *angustifolia* variety of *L. capitata*, with its rounded legumes not surpassed by the calyx and sometimes slender peduncles, it is well separated from that species, but is more likely to be a distinct species than a form of *L. hirta*. As to the "clandestine" or "apetalous" flowers of one section, which Maximowicz would prefer to call "female" (none of which names are truly apt), we request our botanists in the field to scrutinize them. They are probably *cleistogenous*. As to Bertoloni's *L. cytisoides*, it is of course *Pitcheria galactoides* of Nuttall; and we thought this had been stated in this Journal, among the notices of poor old Bertoloni's remarkable doings. As to *L. striata*, the type and sole representative of his third sub genus, *Microlespedeza*, Dr. M. is unaware of the singular fact of its recent, and singular, seemingly unaccountable, naturalization and wide diffusion in our southern Atlantic States, where

it is said to be of inestimable value as a "forage plant." There are notices of it in this Journal, eight or ten years ago: these would have supplied the author of this monograph with materials for amplifying his paragraph upon the use of Lespedezæ. A. G.

17. *On the Systematic Position of the Brachiopoda;* by E. S. MORSE. (From the Proceedings of the Boston Society of Natural History, vol. xv, 1873.) 60 pages, with numerous figures.—In this memoir Professor Morse has presented, at some length, his arguments in favor of uniting the Brachiopods with the Chætopod Worms. His avowed object is "to show that in every point of their structure, the Brachiopoda are true worms, with possibly some affinities to the Crustacea, and that they have no relations to the Mollusca, save what many other worms may possess in common with them."

In this and several other valuable papers on the Brachiopods the author has presented many facts of great interest and importance concerning their anatomy and embryology, and for these he deserves much credit, whether we accept his theories concerning their relations to the worms, or not. A full discussion of his theory and arguments, on this subject, will not be attempted at this time; but as some of his statements are calculated to mislead those not familiar with the subject, a few exceptions to such statements may not be out of place. On pages 7 to 10 (319 to 322, in Proc.) a summary is given of the characters in which Worms and Mollusks are supposed to differ; and on pages 58 and 59, the characters of "Vermes" and Brachiopods are compared in parallel columns. In both places the terms "worms," "Vermes," "Annulata," are used so indefinitely that it is not always easy to tell whether certain characters are intended to apply to all worms, or "vermes," or to particular groups, like the Annelids. But considering the immense diversity in the anatomy and embryology of the numerous groups, of at least ordinal value, if not classes, already referred to the "Vermes," this distinction is of essential importance. Thus it would be easy to show that there are exceptions (often very numerous) to nearly every character given as characteristic of "Vermes" on pp. 58, 59. It would also be easy to show that part of the characters given as common to Vermes and Brachiopods are common, likewise, to most other classes of Invertebrata, including certainly some Mollusks and Radiates.

The first character given (p. 7) relates to form: "We have in the Vermes a form, whose length is much greater in proportion to its breadth than in the Mollusks." Many Annelids, like *Aphrodite*, *Euphrosyne*, certain leeches, and many of the lower "Vermes," like the Planarians, are notable exceptions, being relatively broader and shorter than the majority of Mollusks. Again, "the worm is perfectly bilaterally symmetrical, depressed, flattened or circular, the dorsal and ventral regions so near alike in many cases as to be distinguished with difficulty, and the body never flattened laterally," the reverse being stated of the Mollusks. But we find many Annelids that are more or less asymmetrical, either in the number and form of the jaws (*Diopatra*, etc.), or in the cephalic appendages, as in *Serpulidæ*, where one of the branchiæ, on one side, is often transformed into an operculum; or in various other organs, in different groups; while the dorsal and ventral regions are often quite as strongly contrasted as in any mollusk; and in some cases the body is compressed laterally (*Ammotrypane*). But on the other hand, mollusks are often nearly or quite symmetrical (many Nudibranches, Chitons, Pteropods, Cephalopods) and are frequently cylindrical or even depressed (*Doris*, Chitons, Cephalopods, Pteropods). In fact *form* is a very poor character for characterizing any large group of animals, and should have little or no weight in this case. The ventral connections of the "locomotor muscles" in mollusks and their lateral and dorsal attachment to the integument in worms are given as distinctive. But we generally find the locomotor muscles of animals connected with the locomotive organs, wherever these may be situated. So in *Pecten* we find that the main locomotor muscles are attached laterally to the shell, that being its principal organ of locomotion; and in Cephalopods we find them on the sides and back, as well as ventrally, so that the mantle may be used as a locomotive organ. On the other hand, many worms, like *Aphrodite*, *Lepidonotus*, many leeches, Trematodes, and other worms, both high and low, have their locomotive organs as truly ventral as those of Gastropods. "In the Mollusk the tegumentary envelope is prolonged, and oftentimes continuous, forming a sac or mantle, inclosing a conspicuous cavity, and protecting the gills." This is, indeed, a valuable character, but not accurately stated, for the mantle does not always form a "cavity," and is often nearly or quite abortive, and the gills are often situated on the back or sides, as in the Nudibranchs. But in this character the Brachiopods agree with the Mollusks, and not with the worms. "In the worm the digestive canal is straight, rarely convoluted, and suspended freely in the perivisceral cavity." "In the Mollusk, the intestine is always convoluted, not suspended freely in the perivisceral cavity, but intimately blended, or united with other organs." The intestine varies immensely in both groups, according to the food of the species, and cannot be properly used as a character for separating two sub-kingdoms. Among Sipunculoid Worms (as stated on p. 26) the intestine is generally very long and greatly convoluted, and may terminate either anteriorly or posteriorly.

In most Nemerteans, Planarians, and Trematode worms the intestine is not "freely suspended," but firmly united to the other organs and the tegumentary system. "In Vermes there is a peculiar depuratory apparatus characteristic of all. In the Annulata this apparatus takes the shape of bilaterally symmetrical tubes, in pairs, opening externally and communicating with the perivisceral caviity, by distinct independent infundibuliform orifices. In the Mollusca, with the exception of certain Cephalopoda, nothing of the kind is found, and where such communication does exist between the organs and the surrounding medium, it is by means of simple orifices in the walls of the cavity." The "depuratory apparatus" of "Vermes" is so diverse in structure and position in the different groups, as to render it very questionable whether these organs are homologous in the different orders. Moreover, there is still so much to learn concerning both the proper vascular circulation and the "depuratory apparatus" of ordinary Mollusca, and the connection of both with the exterior, that it is very unsafe to base generalizations on negative evidence of this kind. Even now, the utmost diversity of opinion exists, among the leading European anatomists, concerning the character of these organs in the commonest Mollusks, some asserting and others denying the existence of external vascular connections, lacunæ, capillaries, etc. It should also be considered that no "segmental organs" have yet been detected in the nearest allies of the Annelids, the Crustacea, although the two classes agree so closely in nearly all other respects that no one has been able, as yet, to frame strictly distinctive diagnoses for them. Nevertheless the existence of the infundibuliform organs in Brachiopods is certainly one of their most remarkable characters; and also one of the strongest analogies with the Annelids which they possess.

The character of the nervous system of Brachiopods, according to the author's own statements, is quite as much like that of a degraded mollusk as like that of a degraded worm, and has no special resemblance whatever to that of any of the true Annelids, with which the author wishes to compare them. We may as well compare it with the nervous system of a Lamellibranch, without the pedal and posterior ganglia (for which there is no use), as with that of an Annelid destitute of the ventral series of ganglia. "In the Annulata, with the exception of the Discophora, the generative products are set free in the perivisceral cavity, receiving from the fluid therein contained certain nourishment." Another notable exception is fouud in the common earth-worms, and their allies, which have a distinct oviduct and male organ, in the median line beneath, and, like many leeches, lay eggs enclosed in capsules, not unlike those of many mollusks. Other exceptions also occur in the Annelids, while among the Cestodes, Trematodes, Nematodes, and Turbellaria, the oviduct is usually single and connected directly with the ovary, as in most Mollusca. But in Polyps and many common Fishes, etc., the generative products are discharged into the perivisceral cavity, as in most Chætopod Annelids. This is obviously a character of small importance, hardly sufficient to characterize even the several *orders* of Annelids. In the Mollusca, "with the exception of the Octopoda, the oviduct is single." Many other exceptions occur, in the Chitons, Lamellibranchs, etc. "Among the Mollusks, even when devoid of a shell in the adult, the embryo early develops a shell composed of one or two pieces." This is not the case in many Cephalopods and Pteropods.

From this summary it will be seen that not one of the characters given to worms is, properly speaking, characteristic, or diagnostic, of the Vermes, as a whole, and few of them can be applied to more than a single order, while many of them are common to the worms and various other invertebrates, belonging to diverse classes and branches, including Mollusca. The same remarks apply to most of the additional characters given to Vermes, on pp. 58, 59. Some of the latter are even more useless, as distinctive of Vermes. Thus they are said to have "an extensive vascular system, containing a colored fluid representing the pseudo-hæmal system." This has not usually been given as a character for all Vermes," but merely for the higher Annelids; but it does not hold good even within those limits, for there are many Chætopod Annelids, belonging to several different families, that are totally destitute of pseudo-hæmal vessels, but have only one fluid, which fills the perivisceral cavity, (*Aphlebina*, *Polycirrus*, *Glycera*, etc.), and yet some of these genera belong to families in which other genera have a complete system of vessels, (see also Morse's quotation from Claperède, p. 25). The possession of "chitinous outgrowths, either as scales, plates, hairs, or spines" is a character that applies only to a part of the true Annelids, most leeches and many Sipunculoids, as well as most of the Helminths (except in the embyos of some) being destitute of such appendages. In fact most of these characters are no more characteristic of worms, as a group, than the presence of a shell is characteristic of Mollusca.

These facts are brought forward, not for the purpose of refuting Prof. Morse's views concerning the position of Brachiopoda, which, if established at all, must rest on other and better foundations, but to show how vague are his definitions of "Vermes," and how indefinite his ideas as to what a *worm* really is. The difficulty of defining the heterogeneous group of "Vermes" would be greatly increased by adding to it the Brachiopods and Polyzoa, as the author proposes. Nor can he better the matter, by separating the "Vermes" from the rest of the Articulata, and calling the group a "sub-kingdom," as some other writers have alreany done. In fact, there is far greater difference between the Annelids and lower worms (Helminths), than between the Annelids and Crustacea. These two last classes approximate so closely in structure, in some of their forms, that it has become a matter of extreme difficulty to find diagnostic characters for separating them, and few greater absurdities have been proposed in classification, in modern times, than to separate them in two "sub kingdoms" or branches. On the same basis every class of animals might be made a "sub-kingdom."

Another feature of the arguments presented demands attention from those who may wish to form an impartial judgment of them. The author naturally takes great pains in every case to point out all the resemblances between the organs of worms and those of Brachiopods that he compares, but he does not always allude to the *differences*. Thus, on p. 11, he compares the elongated caudal segments of Annelids, like *Pectinaria* and *Sabellaria*, with the peduncle of Brachiopods, but he does not mention the fact that in the former the anal orifice is at the end of the caudal segment, which is bent forward, and that this elongation is to facilitate the discharge of the fæces; while the peduncle of Brachiopods is imperforate, does not contain the intestine, and is essentially an organ of attachment. The fabrication of tubes by the agglutination of sand with a mucous secretion, in *Lingula*, is a character of trivial importance, for many soft bodied species of nearly all classes of invertebrates, whether Protozoa, Radiata, Mollusca, or Articulata, do the same thing. On p. 28, the identity of the cirri of Brachiopods and Annelids is asserted, but he has not mentioned that in the latter these organs are genuine gills, with a complicated capillary vascular circulation, which has not been shown to exist in the former. So of the pallial membranes of Brachiopods and the collar of Annelids, he has shown their points of resemblance, but has largely ignored their great differences in structure, relations, and function. We would also remind our readers that a liberal use of printers-ink on diagramatic cuts, like those on page 21, may serve to conceal differences, as well as to show resemblances.

The facts in regard to the embryology of the Brachiopods, which are brought out by Prof. Morse in this and in a subsequent memoir, are of great interest and importance, and do, indeed, show remarkable points of resemblance between the embryos and larvæ of Brachiopods and of certain worms. A. E. V.

18. *Occurrence of Gigantic Cuttle-fishes on the coast of Newfoundland;* by A. E. VERRILL.—Considerable popular interest has been excited by several articles that have recently been published and extensively circulated in the newspapers of Canada and the United States, in regard to the appearance of gigantic "squids" on the Newfoundland coast. Having been so fortunate as to obtain, through the kindness of Prof. S. F. Baird, the jaws and other parts of two of these creatures, and, through the courtesy of Dr. J. W. Dawson, photographs of portions of two other specimens, I have thought it worth while to bring together, at this time, the main facts respecting the several specimens that have been seen or captured recently, so far as I have been able to collate them, reserving for a future article the full descriptions and figures of the jaws and other portions, now in my possession.

We now have reliable information concerning five different examples of these monsters that have appeared within a short period, at Newfoundland. (1). A specimen found floating at the surface, at the Grand Banks, in October, 1871, by Captain Campbell, of the schooner B. D. Haskins, of Gloucester, Mass. It was taken on board and part of it used for bait. Dr. A. S. Packard has given, in the American Naturalist, vol. vii, p. 91, Feb., 1873, all the facts that have been published in regard to this individual. But its jaws have since been sent to the Smithsonian Institution, and are now in my hands to be described and figured. They were thought by Professor Steenstrup, who saw a photograph of them, to belong to his *Architeuthis monachus*, which inhabits the northern coasts of Europe, but is still very imperfectly known. The horny jaw or beak from this specimen is thick and strong, nearly black; it is acute at the apex, with a decided notch or angle on the inside, about ·75 of an inch from the point, and beyond the notch is a large prominent angular lobe. The body of the specimen from which this jaw was taken is stated to have measured 15 feet in length and 4 feet 8 inches in circumference. The arms were mutilated, but the portions remaining were estimated to be 9 or 10 feet long, and 22 inches in circumference, two being shorter than the rest. It was estimated to weigh 2000 pounds.

(2). A large individual attacked two men, who were in a small boat, in Conception Bay, and two of the arms which it threw across the boat were cut off with a hatchet, and brought ashore. Full accounts of this adventure, written by Mr. M. Harvey, have been published in many of the newspapers.* One of the severed arms, or a part of it, was preserved in the museum at St. John, and a photograph of it is now before me. This fragment represents the distal half of one of the long tentacular-arms, with its expanded terminal portion covered with suckers, 24 of which are larger, in two rows, with the border not serrate, but 1·25 inch in diameter; the others are smaller, very numerous, with the edge supported by a serrated calcareous ring. The part of the arm preserved measured 19 feet in length, and 3·5 inches in circumference, but wider, "like an oar," and 6 inches in circumference, near the end where the suckers are situated; but its length, when entire, was estimated at 42 feet.† The other arm was destroyed and no description was made, but it was said to have been 6 feet long and 10 inches in diameter; it was evidently one of the eight shorter sessile arms. The estimate given for the length of the "body" of this creature (60 feet) was probably intended for the *entire length*, including the arms.

(3). A specimen was found alive in shallow water, at Coomb's Cove, and captured. Concerning this one I have seen only newspaper accounts. It is stated that its body measured ten feet in length and was "nearly as large round as a hogshead" (10 to 12 feet); its two long arms (of which only one remained) were forty-two feet in length and "as large as a man's wrist;" its short arms were six feet in length, but about nine inches in diameter, "very stout and strong;" the suckers had a serrated edge. The color was reddish. The loss of one long arm and the correspondence of the other in size to the one amputated from No. 2, justifies a suspicion that this was actually the same individual that attacked the boat. But if not, it was probably one of the same species, and of about the same size.

* Also in the Annals and Magazine of Natural History, January, 1874, with a wood-cut of the arm.

† Doubtless these long arms are very contractile and changeable in length like those of the ordinary squids.

(4). A pair of jaws and two of the suckers were recently forwarded to me from the Smithsonian Institution. These were received from Rev. A. Munn, who writes that they were taken from a specimen that came ashore at Bonavista Bay; that it measured thirty-two feet in length (probably the entire length, including more or less of the arms); and about six feet in circumference. This jaw is large and broad, but much thinner than that of No. 1, and without the deep notch and angular lobe seen in that specimen. It probably belongs to the *Architeuthis dux* of Steenstrup, or at least to the same species as the jaw figured by Dr. Packard.

(5). A smaller specimen, captured in December, in Logic Bay, about three miles from St. John, in herring nets. Of this I have a description in a letter to Dr. Dawson, from M. Harvey, Esq., who has also published a brief account of it in the "Morning Chronicle," of St. John. The letter is acompanied by two photographs of the specimen: one showing the entire body, somewhat mutilated anteriorly; the other showing the head with the ten arms attached. The body of this specimen was over seven feet long, and between five and six feet in circumference; the caudal fin was twenty-two inches broad, but short, thick, and emarginate posteriorly on each side, the end of the body being acute; the two long tentacular-arms were twenty-four feet in length, and two and a half inches in circumference, except at the broader part near the end; the tips slender and acute; the largest suckers 1·25 inch in diameter, with serrated edges; the eight short arms were each six feet long; the two largest were ten inches in circumference at base; the others were 9, 8 and 7 inches. These short arms taper to slender acute tips, and each bears about 100 large, bell-shaped suckers, with serrated margins. Each of the long arms bear, about 160 suckers on the broad terminal portion, all of which are denticulated; the largest ones, which form two regular alternating rows, of twelve each, are about an inch in diameter. There is also an outer row of much smaller suckers, alternating with the large ones, on each margin; the terminal part of these arms is thickly covered with small suckers: and numerous similar small suckers are crowded on that portion of the arms where the enlargement begins, before the commencement of the rows of large suckers. The arrangement of the suckers is nearly the same as on the long arm of No. 2, but in the latter the terminal portion of the arm, beyond the large suckers, as shown in the photographs, is not so long, tapering, and acute, but this may be due to the different conditions of the two specimens. It is probable that this was a young specimen of the same species as No. 2.

From the facts known at present, it appears probable that all these specimens, and several others that have been reported at various times from the same region, are referable to two species; one (probably *Architeuthis monachus*) represented only by the first of those enumerated above, and having a more elongated form of body and stouter jaws; the second (probably *A. dux*) represented by Nos. 2 to 5, above described, having a short, thick, massive body, and broad, but comparatively thin jaws, which are also different in form. Some of the differences in size and proportions, and in the suckers, observed among the four specimens referred to the latter species, may be due to sex, for the sexes differ considerably in these characters in all known cuttle-fishes.

19. *Revision of the Echini;* by ALEXANDER AGASSIZ. Part iii, 4to, with 45 plates. Illustrated Catalogue of the Museum of Comparative Zoölogy. Cambridge, Mass. 1873.—This excellent work is profusely illustrated by unique plates, a large part of which have been made by different photographic printing processes, directly from photographs of the specimens, and are of unrivalled excellence. The Woodbury-type process, the Albert-type and the Heliotype, have all been successfully employed, while superior lithographs have also been used to some extent. Part iii. contains detailed descriptions of all the known species, except those of the east coast of North America, which were described in Part ii. Such species are, however, referred to, in their proper systematic places. Twenty-eight plates illustrate Part iii; the remaining seventeen relate to structure and belong to Part iv, but are issued in advance of the text, owing to the loss of the MSS., drawings, and some of the plates, by the great Boston fire, in November, 1872. A. E. V.

20. *The Marine Mammals of the Northwestern Coast of North America, described and illustrated, together with an account of the American Whale-fishery;* by CHARLES M. SCAMMON, Captain U. S. Revenue Marine. San Francisco: John H Carmany & Co. 4to.—The advance copies of the plates of this work, that we have seen, are highly satisfactory, and considering the well known ability and enthusiasm of the author, we anticipate that the book, when completed, will be a valuable contribution to science, in a department which is still very imperfectly understood, and of great importance economically. The work deserves, and should receive, the support of all who are interested in promoting the study of Natural History. It is to be illustrated by thirty or more lithographic plates, and is offered to subscribers at the very low cost of ten dollars. A. E. V.

21. *Embryology of Terebratulina;* by E. S. MORSE. From the memoirs of the Boston Society of Natural History, vol. ii, p. 249–264, 4to, with two steel plates. December, 1873.—A longer notice of this important memoir is deferred to the next number.

22. *Crustacea common to Lake Superior and the lakes of northern Europe;* by S. I. SMITH.—The occurrence of *Mysis relicta* Lovén and *Pontoporeia affinis* Lindström in Lakes Superior and Michigan has already been alluded to in this Journal (vol. ii, pp. 373 and 448, Nov. and Dec., 1871). In recently examining the collection made in Lake Superior in 1871, under the direction of the Superintendent of the Lake Survey, I have found three species of Cladocera which I cannot distinguish from species described from the lakes of northern Europe. *Daphnia galeata* G. O. Sars

and *D. pellucida* P. E. Müller were taken at the surface a few miles south of the island of St. Ignace and also came up in the dredge at the same locality. These species both agree fully with the detailed figures and descriptions given by Müller.*

A single specimen of *Leptodora hyalina* Lilljeborg† came up in the dredge with the last species and, like them, was undoubtedly taken in the dredge on its way up. This last species is one of the largest and most remarkable forms of Cladocera known. It is wholly transparent and grows to fully half an inch in length. The shell is very small and incloses no part of the body; the head with the large eye at its extremity is produced far forward; the basal portion in the natatory appendages is long and very stout, while the rami are comparatively short and four-jointed; the six pairs of legs are crowded together below the natatory appendages; and the abdomen is very long and the last segment terminates in two stout stylets.

23. *The American Limulus polyphemus on the Dutch coast.*—This species of Limulus, familiarly known on the American coast as the Horse-shoe or King-crab was taken in July last, according to Mr. Edward Newman, about eleven miles off the Shelling Light on the Dutch coast, by the Yarmouth trawl boats. Four or five have been taken in all during the summer. One is reported to have been captured on the coast of North Wales.—*Harper's Weekly*, Jan. 24.

III. Astronomy.

1. *Contributions to Solar Physics.* I. A popular Account of Inquiries into the physical constitution of the Sun, with special reference to recent Spectroscopic Researches; II. Communications to the Royal Society of London and the French Academy of Sciences, with Notes. By J. Norman Lockyer, F.R.S. London: Macmillan and Co. 1874. pp. xxi, 676, 8vo.—The purpose of this beautiful volume, which has just been issued by Messrs. Macmillan and Co., is sufficiently indicated in the above title to render any extended notice unnecessary. The first part is a popular exposition of the facts and principles necessary to a good understanding, on the part of the general reader, of the recent acquisitions in spectroscopy, and the results of its application to the study of solar physics. It is made up, for the most part, of lectures of the author delivered at the Royal Institution and elsewhere, upon the sun, solar eclipses, and the spectroscope, and of essays which he has published at different times in various periodicals. The second part contains, besides the numerous papers of the author giving account of his own researches and discoveries, copious statements of the part other investigators have had in the achievements of spectroscopic analysis, and its application. The

* Denmark's Cladocera, Naturhistorisk Tidsskrift, III, vol. v, p. 116, 117, pl. 1, figs. 5, 6.

† Oversight af Kongl. Vetenskaps-Akademiens Förhandlingar, 1860. p. 265, pl. 7, figs. 1–22; Müller, loc. cit., p. 226, pl. 6, figs. 14–21.

work is enriched with numerous illustrations and maps of spectra, and much new matter is added in the notes. The manner in which this portion of the work is made up gives it especial value, as it is not a mere *résumé*, but gives the original papers either fully, or in extended extracts. Information of the highest interest is thus brought to readers, to most of whom, perhaps, the original memoirs are inaccessible. A. W. W.

2. *The Analyst: a Monthly Journal of Pure and applied Mathematics;* edited and published by J. E. HENDRICKS, A.M., Des Moines, Iowa.—This is the first number of a journal "intended to afford a medium for the presentation and analysis of any and all questions of interest or importance in pure and applied mathematics, embracing especially, all new and interesting discoveries in theoretical and practical astronomy, mechanical philosophy, and engineering." Each number is to consist of not less than sixteen pages, and the price is two dollars a year. Among the articles in this number are: the relative positions of the asteroidal orbits, by Prof. Kirkwood; the recurrence of eclipses, by Prof. D. Trowbridge; operations on imaginary quantities considered geometrically, by Prof. Henkle; equations of differences, by Mr. Siverly; relation between the mean and true anomaly, by Prof. Ficklin; etc. A journal covering this field is needed in this country, and we most heartily wish it the highest success.

3. *An investigation of the Orbit of Uranus, with general tables of its Motion;* by SIMON NEWCOMB, Prof. Mathematics, U. S. N. Smithsonian Contributions. 4to, pp. 288.—The first chapter of this elaborate work, is a development of a method of determining the pertubations of the longitude, radius vector and latitude of a planet by direct investigation. This theory is then applied to the action of the three other large planets upon Uranus. An exhaustive discussion of all the good observations of the planet from 1690 onward, and extended tables of its motion complete the work.

4. *Astronomical Suggestions;* by H. M. PARKHURST.—(1.) By the method of "extinguishing apertures," accuracy of results can only be obtained with a perfectly dark field. It is evident that a star is more easily seen in a black field than in one which is illuminated; and that, with an equal magnifying power the illumination will vary in proportion to the aperture. The error may exceed one magnitude.

(2.) A transit may be observed by the spectroscope when there is a near approach but no actual contact. This method will not be applicable to a transit of Venus before the year 2490; but may be applied to transits of Mercury or the moon. Mercury in the conjunction of Nov., 1874, will pass near the sun's limb, but probably not near enough to be seen.

5. *Astronomical Engravings from the Observatory of Harvard College.*—We omitted to notice some weeks since the receipt of Nos. 20–22 of this series (see this Journal, v, 319), which contain representations of the lunar mountains Linné, Gassendi, Plato, Aristarchus and Herodotus, a key to the lunar surface, and four views of the planet Mars.

6. *Tableau de l'Astronomie dans l'Hémisphère Austral et dans l'Inde;* by Dr. E. Mailly, Bruxelles, 8vo, pp. 232. Extract from the 23d vol. of Memoirs of the Royal Academy of Belgium.—This is an interesting and minute account of the equipment of all the observations in the southern hemisphere and India, with the work accomplished in each from Halley's formation of a catalogue at St. Helena in 1677, of 341 southern stars, to the establishment of the observatory at Cordoba, by Dr. Gould.

7. *Aurora Australis.*—The Aurora was seen at Sandhurst in Victoria, on the 19th of May, 1873, at 10 p. m.—*Monthly Record Melbourne Observatory, during May,* 1873.

IV. Miscellaneous Scientific Intelligence.

1. *American Metrological Society.*—On the 30th of December, a number of gentlemen met at Columbia College, pursuant to a call issued by Pres. F. A. P. Barnard, and formed the *American Metrological Society.* Hon. J. A. Kasson presided, and a constitution was adopted and officers elected. The objects of the society are stated to be to originate measures or to aid in promoting measures elsewhere originating, designed to improve the system of weights, measures, and moneys at present existing among men, and to bring the same into relations of simple commensurability with each other.

An object secondary to this will be to secure the universal adoption of common units of measures for the expression of quantities which require to be stated in presenting the results of physical observation or investigation, and for which the ordinary systems of metrology do not provide—such as the divisions of the barometer, thermometer, and densimeter; the amount of work done by machines; the amount of mechanical energy, active or potential, of bodies, as dependent on their motion or position; the quantities of heat present in bodies at given temperatures or generated by combustion or otherwise; the quantity and intensity of electro-dynamic currents; the aggregate or efficient power of prime movers; the accelerative power of gravity; the pressure of steam and of the atmosphere, and other matters analogous to these. The Association will endeavor also to secure uniformity of usage in regard to standard points of reference, or to those physical conditions to which observations must be reduced for purposes of comparison, especially the temperature and pressure to which are referred the specific gravities of bodies and the zero of longitude on the earth. The following officers were chosen:

President, Dr. F. A. P. Barnard; *Vice-President,* Hon. John A. Kasson; *Recording Secretary,* Prof. C. G. Rockwood. Jr.; *Corresponding Secretary,* Prof. S. D. Tillman; *Treasurer,* Howard Potter, Esq.; *Council,* S. B. Ruggles, Esq., Profs. H. A. Newton, T. R. Pynchon, J. E. Hilgard, Wolcott Gibbs, and C. S. Lyman, E. B. Elliott, Esq., Profs. J. P. Cooke, R. W. Raymond, and R. H. Thurston.

2. *Gold and Silver production in* 1873.—Mr. JOHN J. VALENTINE, General Superintendent of Wells, Fargo & Co. Express agency, through whose hands most of the bullion of the Pacific coast of North America passes, has furnished the "Alta California," of Jan. 1, 1874, with the following tabular statement of the precious metals for 1873.

Statement of Precious Metals produced in States and Territories West of Missouri River, during 1873.

States and Territories.	Gold Dust and Bullion by Express.	Gold Dust and Bullion by other conveyances.	Silver Bullion by Express.	Ores and Base Bullion by Freight.	Total.
California	$15,709,956	$1,570,995	$ 264,771	$480,000	$18,025,722
Nevada	219,141	43,828	30,183,921	4,807,617	35,254,507
Oregon	1,146,991	229,398	--------	------	1,376,389
Washington	171,951	34,390	3,054	------	209,395
Idaho	1,171,131	234,226	938,297	------	2,343,654
Montana	3,241,238	648,247	3,325	------	3,892,810
Utah	112,003	22,400	1,210,434	3,561,500	4,906,237
Arizona	37,074	7,415	3,289	------	47,778
Colorado	1,856,639	--------	839,862	1,386,767	4,083,268
Mexico	--------	--------	868,798	------	868,798
British Columbia	1,041,696	208,339	--------	------	1,250,035
Total	--------	--------	--------	------	$72,258,693

This aggregate is over $10,000,000 in excess of the like statement for 1872. The increase in Nevada alone is nearly $10,000,000, and the total product of Nevada nearly equals that of all the others. Arizona, California, British Columbia, Oregon, Washington, Idaho and Montana have diminished. Nevada, Utah and Colorado increased. Arizona is imperfectly represented, but her entire production is small at most. The production of Mexico is represented very imperfectly and in silver only, because the great bulk of the bullion of Mexico reaches market by other channels than Wells, Fargo & Co., who report only what they have themselves transported. The combined product of all shows for 1872, $62,236,913 and for 1873, $72,258,693, which exceeds the product of any previous year for these regions.

3. *United States Geological Survey of the Territories.*—The United States Geological Survey of the Territories has in press at this time, at the Government Printing office, the following works.

A volume on the Ornithology of the northwestern territories. It has been prepared by Dr. E. Coues, the well known ornithologist. The synonomy has been worked out with care and the descriptions are given of four-fifths of the birds known to exist west of the Mississippi. The volume will form, No. 3 "Miscellaneous Publications," and will contain from 800 to 1000 pages, 8vo. It will not be ready for distribution before Spring.

No. 4 of the "Miscellaneous Publications," the Synopsis of the Flora of Colorado by Prof. T. C. Porter and John M. Coulter, is in type and will be ready in a few days. It will form an octavo volume of about 250 closely printed pages, and contain a list of over 1400 species. "The plan followed in the Synopsis is, that of Mr. Watson in his excellent Catologue vol., 5, of Clarence King's Report. Descriptions are given of all the orders, genera and species not contained in Gray's Manual, Chapman's Flora, and other Botanies of the States east of the Mississippi river." The mosses, lichens, and fungi are included. About fourteen new species are here described for the first time. The work will form a convenient hand-book for botanical tourists to the mountainous districts of Colorado.

Volume vii of the quarto series, on the Cretaceous Flora of the West, prepared by Leo Lesquereux, will be ready for the printer by the end of January. The plates, 28 in number, have been engraved on stone by Mr. Julius Bien, of New York, and will be printed in tints.

It is stated to be the intention of the Survey that the quarto series shall be published in the best style, both as to printing, quality of paper, and character of illustrations.

4. *First Book of Geology;* by WILLIAM S. DAVIS, LL.D., Head Master of the Derby Central School of Science. 160 pp. 12mo, with 115 illustrations.—Putnam's Elementary Science Series. New York (G. P. Putnam's Sons). Reprinted from the English edition. A good little geological school book, based in its stratigraphical and historical part mainly on facts in British geology.

5. *Das Elbthalgebirge in Sachsen von* Dr. H. B. GEINITZ. Cassel, 1873. (Theodore Fischer.)—The sixth number of Part I, and the third of Part II, of Dr. Geinitz's important work have been issued. The former contains a continuation on the Pelecypoda of the Lower Quader (Middle Cretaceous) and is well illustrated by seven quarto plates, partly by Miss Elise Geinitz. The latter treats of species of the same tribe from the Middle and Upper Quader (Upper Cretaceous) and includes six plates.

6. *Academy of Sciences of France.*—J. Norman Lockyer has been elected a correspondent, to fill the place rendered vacant in the Astronomical section by the death of Encke: and Messieurs Angström and Billet in place of Hansteen and Wheatstone.

Reliquiæ Aquitanicæ, being contributions to the Archæology and Palæontology of Périgord and the adjoining provinces of Southern France; by Edouard Lartet and Henry Christy; edited by Thomas Rupert Jones, R.S. and G.S., etc. Part XIII, Nov., 1873; pages 173–188 and 153–164. Plates A. xxxvii–xxxix, and B xxv–xxvii. This new number of the Reliquiæ Aquitanicæ has recently been received.

ERRATA.

Vol. v, p. 432, 22d line from foot, for synclinal, read anticlinal.

p. 419, line 4 from foot, for 14·51 read 14·15.

p. 424, line 11 from foot, dele "and subtracting 1."

p. 425, in the note read—Q in this paper$=\mathfrak{B}$ of Maxwell; $Q'=Q$ of Maxwell; $4\pi M=\mathfrak{H}$ of Maxwell; $\frac{Q}{4\pi}-M=\mathfrak{J}$ of Maxwell.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XVII.—*On the great Lava-flood of the West; and on the structure and Age of the Cascade Mountains;* by JOSEPH LECONTE, Professor of Geology, University of California.

DURING the past summer, I made a geological tour through portions of central and eastern Oregon, the principal object of which was to examine the great lava-flood which covers this region, and more especially to study the structure and determine the age of the Cascade Mountains. In this tour I was accompanied and greatly assisted by Rev. Mr. Condon of the Dalles, a man widely known and greatly honored, no less for his disinterested courtesy than for his extensive knowledge of the geology of this portion of the State. Two years before, I went over nearly the same ground, and also extended my observations into Washington and British Columbia. The purpose of my last visit was to solve, if possible, some of the questions started in the first visit.

I. *The great Lava-flood.**

Extent.—As already stated in my paper on the "great features of the earth surface,"† this is probably the most extraordinary lava-flood in the world. Commencing in middle California as separate streams, in northern California it becomes a flood flowing over and completely mantling the smaller inequalities, and flowing around the greater inequalities of surface, while in northern Oregon and Washington it becomes an abso-

* I use the word *lava* here, and elsewhere in this paper, as synonymous with eruptive rocks.

† This Journal, vol. iv, p. 470.

lutely universal flood, beneath which the whole original face of the country, with its hills and dales, mountains and valleys, lies buried several thousand feet. It covers the greater portion of northern California and northwestern Nevada, nearly the whole of Oregon, Washington and Idaho, and runs far into Montana on the east and British Columbia on the north. Its eastern and northern limits are not well known, but its extent cannot be less than 200,000 to 300,000 square miles, i. e., greater than the whole area of France, or nearly double the area of California.

Source.—This immense mass of liquid matter was derived from streams which issued, as I believe, from *fissures;* some of them in the Coast Range, but mostly in the Cascade and Blue Mountain Ranges. The streams from these two latter sources especially flowed until they met and formed an almost universal sheet.

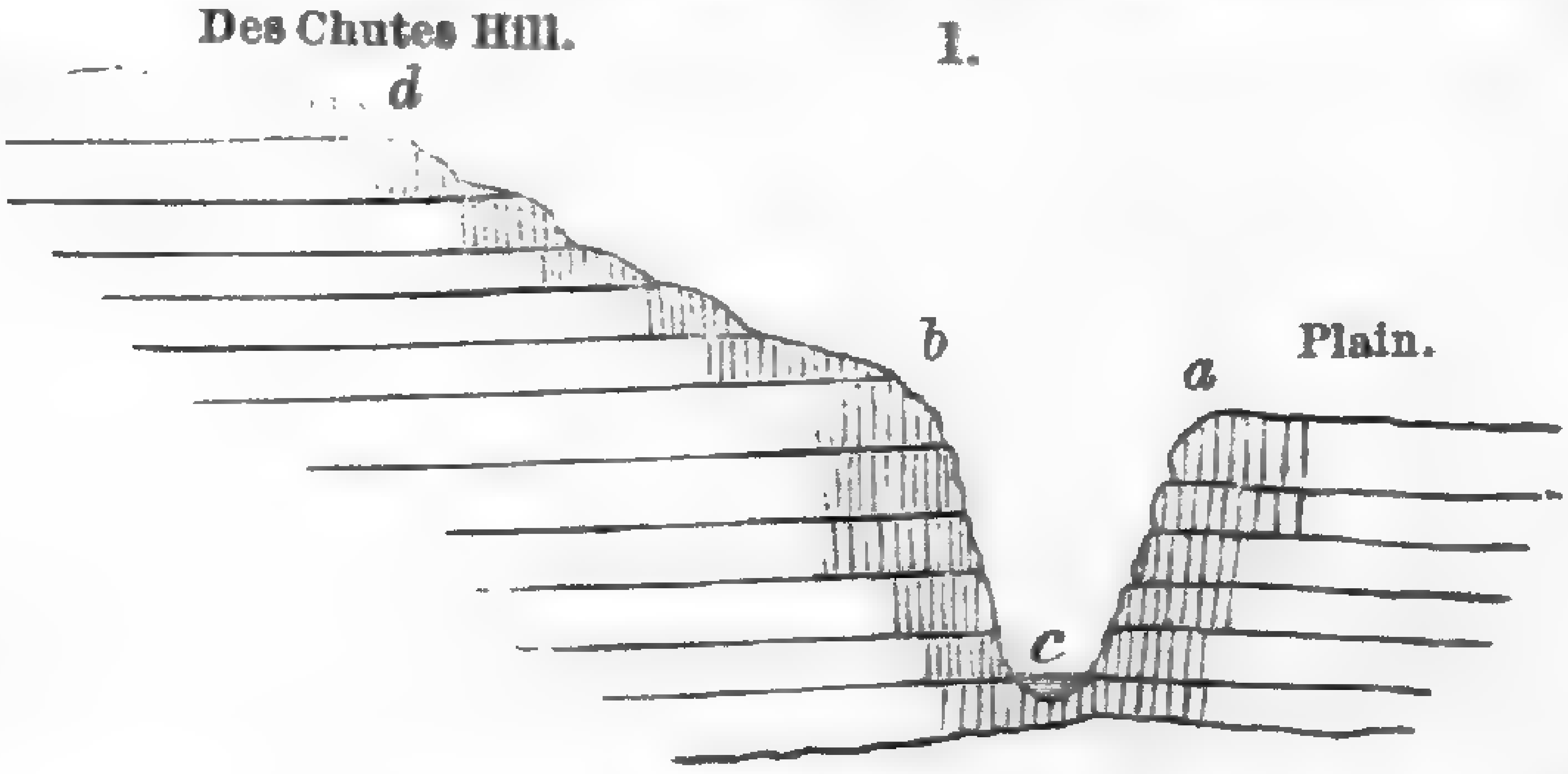
Thickness.—The greatest eruptive activity seems to have been in the region of the Cascade Range, and here therefore the flood seems to have reached its greatest depth. The area covered by the Cascade flows alone cannot be less than .00,000 square miles and the *extreme thickness is not less than* 3700 *feet.* The average thickness over the whole area is probably 2,000 feet. As this seems an extraordinary statement, we will briefly give the evidence on which it rests.

The Columbia River, in its way from the interior plains to the sea, cuts through the Cascade Range *nearly to its very base*; for in this region the river surface is not more than 100 feet above the sea level. In all this portion of its course, for 100 miles, the river runs in a gorge, the perpendicular cliffs of which give a magnificent section of the Cascade Range from top to bottom. At the cascades of the river, which are in the very axis of the range, the cliff peaks have, many of them, been measured by the U. S. engineers connected with the Pacific Railroad explorations. They vary from 2,500 to 3,800 feet above the river surface. For twenty miles above and below this point, the higher peaks rise to 2,000 feet. This grand section reveals the fact that this mighty range is composed wholly of lava, tier upon tier, from top to bottom. In one place only, viz: in the axis of the range, and that only for about two miles along the river, is the bottom of the lava reached by erosion. Here then, leaving off 100 feet of the underlying rock, which we will describe hereafter, we have a clear section of 3,700 feet of lava. And when we recollect that these peaks themselves are produced wholly by unequal erosion, as is plainly shown by the continuity of the planes of the lava layers from peak to peak, surely 4,000 feet is a moderate estimate for the original thickness of the lava flood at this part.

Nor is this thickness very exceptional for the lava of the Cascade Range. We have already said that the higher points of the lava cliffs of the Columbia cañon for near fifty miles are not less than 2,000 feet. But, in order to make this clearer, we will take another section which we examined, at some distance both from the axis of the range and from the Columbia River, viz: the *Des Chutes River section.*

The Des Chutes River is a large tributary of the Columbia, which, rising in southern Oregon, flows northward, parallel to the Cascade Range on the east side and at a distance from its axis of at least fifty miles. The region lying between the crest of the Cascade and the Des Chutes River is mountainous; but this mountainous region stops suddenly at the river, and beyond stretches, as far as the eye can reach, a nearly level lava-covered plain. Right along the line of contact between the mountain and the plain, the river has cut for itself, for more than 100 miles, a deep, extremely narrow gorge (fig. 1, *a*, *b*, *c*)

1.



with nearly perpendicular walls 1,000 feet high, formed wholly of beautifully columnar basalt, arranged tier upon tier, from bottom to top, the hardest and most beautifully columnar of all being in *the bed of the river*, *c.* Back from the edge of this precipice, on the east side, *a*, runs the plains, but on the west side, *b*, at the point examined by me—the upper bridge—the ground continues to rise with a gentler slope about 1,000 feet more, to the top of Des Chutes hill, *d.* Throughout the whole height, from the river bed to the top of Des Chutes hill, the edges of lava layers outcrop. I do not know the precise height of this hill above the river, but it cannot be less than 2,000 feet. I believe it is nearer 3,000 feet. Here then we have again, at a point 50 miles distant from the axis of the range and 30 miles from the Columbia River, a clear section of basaltic lava 2,000 to 3,000 feet thick, and *the bottom not yet reached.*

Beyond the Des Chutes, a nearly level lava plain, covered only with northern drift, stretches away eastward for 30 or 40 miles. This plain is intersected in all directions with deep, narrow stream-gorges, which do not reach the bottom of the lava. Over the whole plain the lava cannot be less than 1,000 feet thick. Beyond the Des Chutes plains and separated from them by a lava ridge, stretches, for twenty miles more, to the base of the Blue Mountains, the region drained by the tributaries of the John Day River. Here the flows from the Cascades meet and mingle with those from the Blue Mountains, and both with *local* fissure eruptions. The lava in this region is less thick, only about 600 to 700 feet; and being underlaid by the remarkable fossiliferous Miocene lake deposit of the John Day Valley, erosion has cut through the lava cap into the soft strata beneath, giving rise to that extraordinary jumble of steep round hills, some capped with lava and some uncapped, called in the expressive vernacular, "the devil's potatoe patch." Imagine a patch twenty miles square, thickly covered with potatoe hills 1,000 feet high, and we have some idea of the extraordinary appearance of this region, as seen from the dividing ridge mentioned above.

Beyond this region I have not followed the lava flood; but others have traced it over a large part of the basin of the Columbia and especially of the Snake River. Clarence King traced it for 300 miles along the Snake River, where it is 700 feet thick.

II. *Structure of the Cascade Mountains.*

The Cascade Mountains, in the region of the Columbia River, with the exception of a very small portion at its very base and in its axis, is composed wholly of lava layers piled one atop another to a height of nearly 4,000 feet. Through this immense mass of lava, the river, whether in the form of ice-stream or water-stream, or both, has cut its way for 100 miles nearly to the sea-level, forming a cañon of unsurpassed magnificence. At the cascades of the river, which is in the very axis of the range, the base of the lava has been reached for a little distance, and *the original surface upon which the lava was outpoured is revealed.* Examination of the sub-lava material fixes, I think, with more certainty than has yet been done, the date of the Cascade lava-flood, and, therefore, the age of the Cascade Mountains. This point is so important, that I must give the evidence in some detail.

In August, 1871, under the guidance of Mr. Condon, I first examined the magnificent section of the Cascade Mountains made by the Columbia River at this point. The navigation of the river is obstructed here by a succession of rapids (called the Cascades), by which it falls about 50 feet in three miles. The upper and lower steamboat landings are connected by a short railroad on the northern or Washington side. The river current washes strongly against the south wall of the cañon, forming a perpendicular cliff on that side. The point first visited by us was nearly opposite the lower steamboat landing. The section here revealed is of the extremest interest. In figs. 2 and 3 I give rude sketches of the face of the cliff (fig. 2) and

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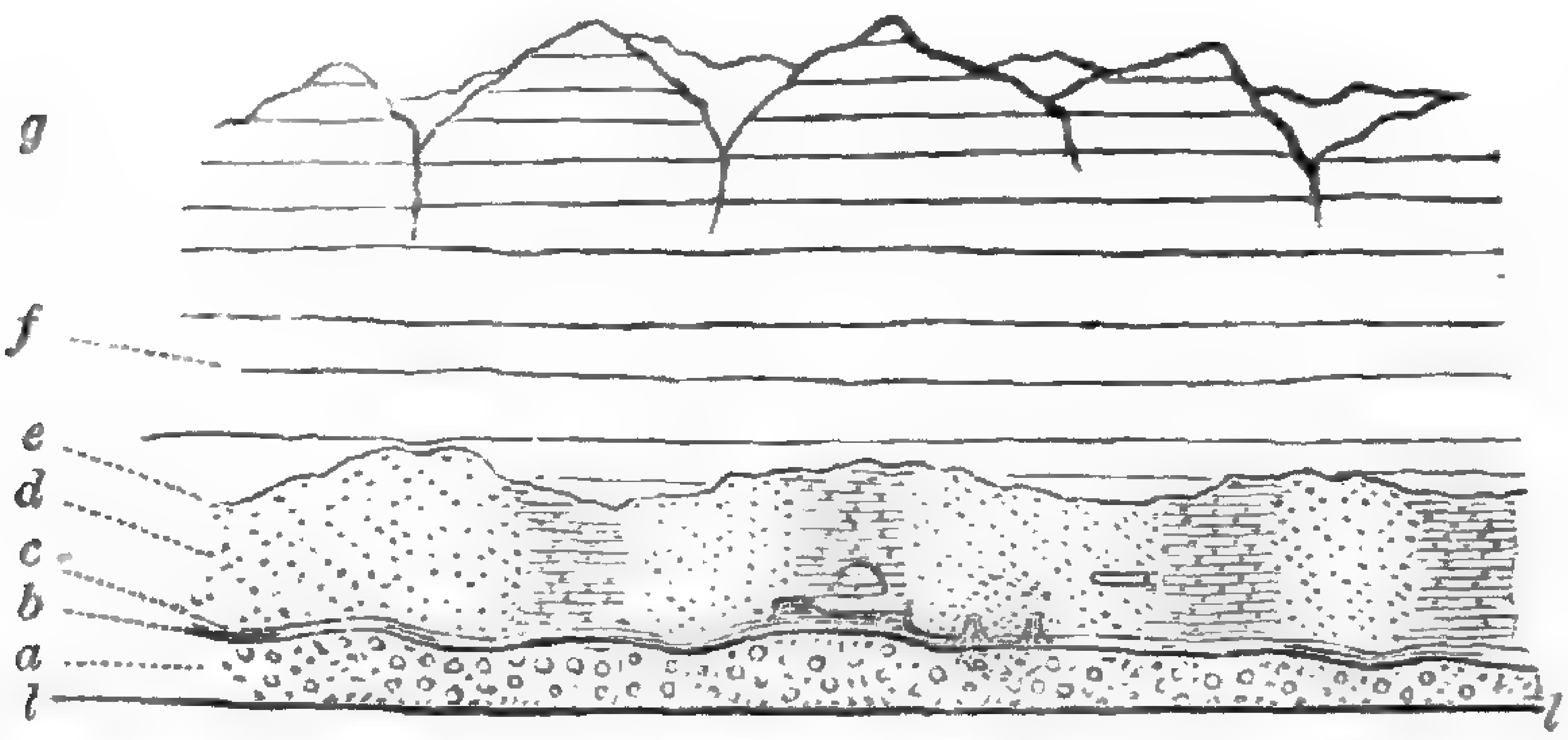
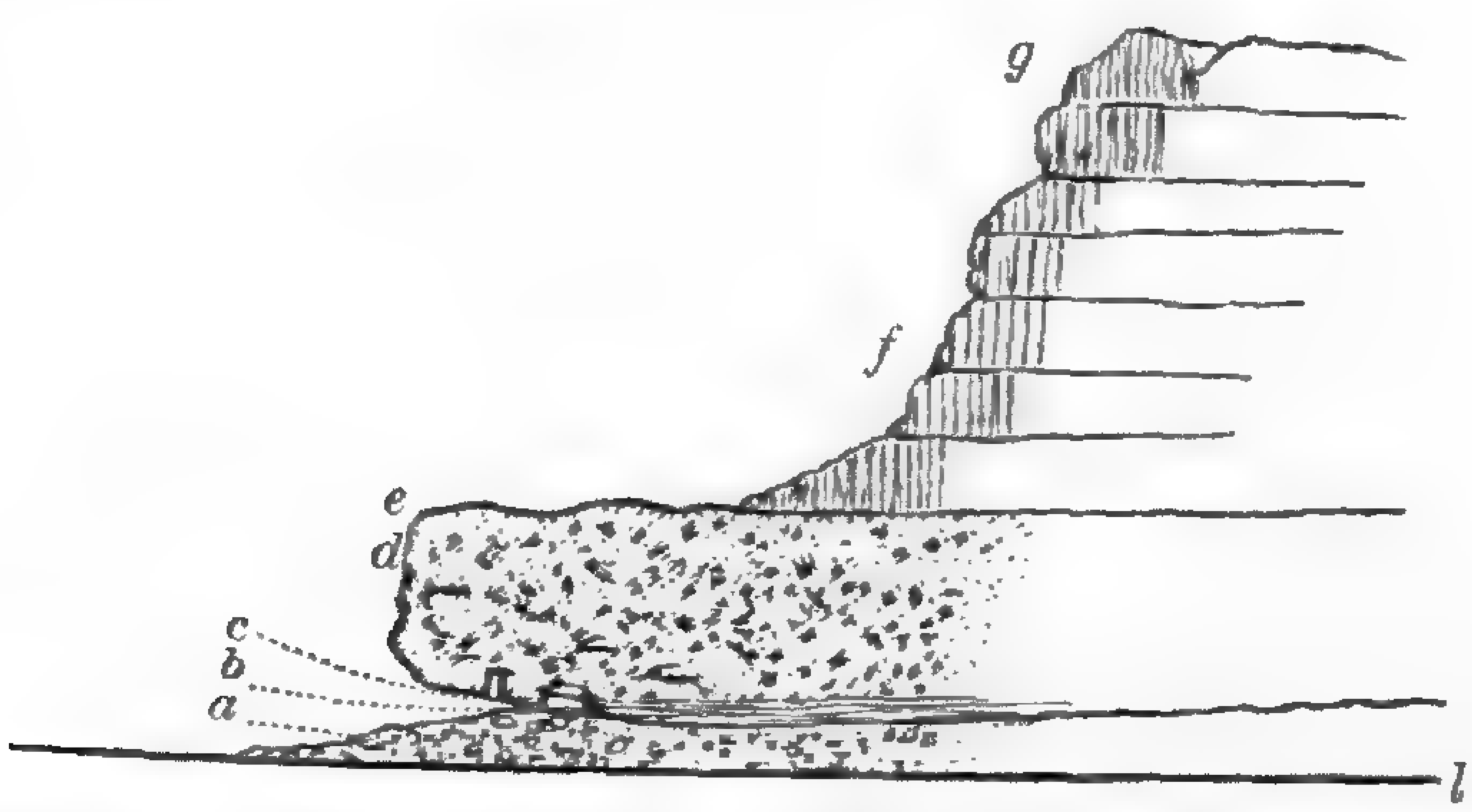


of a section at right angles to the face (fig. 3). These sketches make no attempt at accuracy in form or proportion. They are

3.



merely diagrams intended to render the following description more easily intelligible.

1. Along the water's edge, *l l*, and upward about 15 feet, we found a very coarse conglomerate (*a*) of rounded porphyritic pebbles and boulders of all sizes up to five or six feet in diameter, cohering by an imperfectly lithified earthy paste.

2. The conglomerate, *a*, was limited above by a very distinct irregular dark line, *b*, traceable for a mile or more along the river, which had all the characters of a dirt-bed or old ground surface. On this ground surface were found in an erect position two silicified stumps, with their roots spread out and penetrating the boulder material, *a*, beneath, and therefore evidently *in situ*. One of these is at least two feet in diameter, and its spreading roots could be traced over an area of 20 feet diameter. The roots of the other and smaller one was traceable four or five feet. Besides these two, there were three other vertical trunks in the ôverhanging cliff, the roots of which I suppose had been washed away by the river at high water.

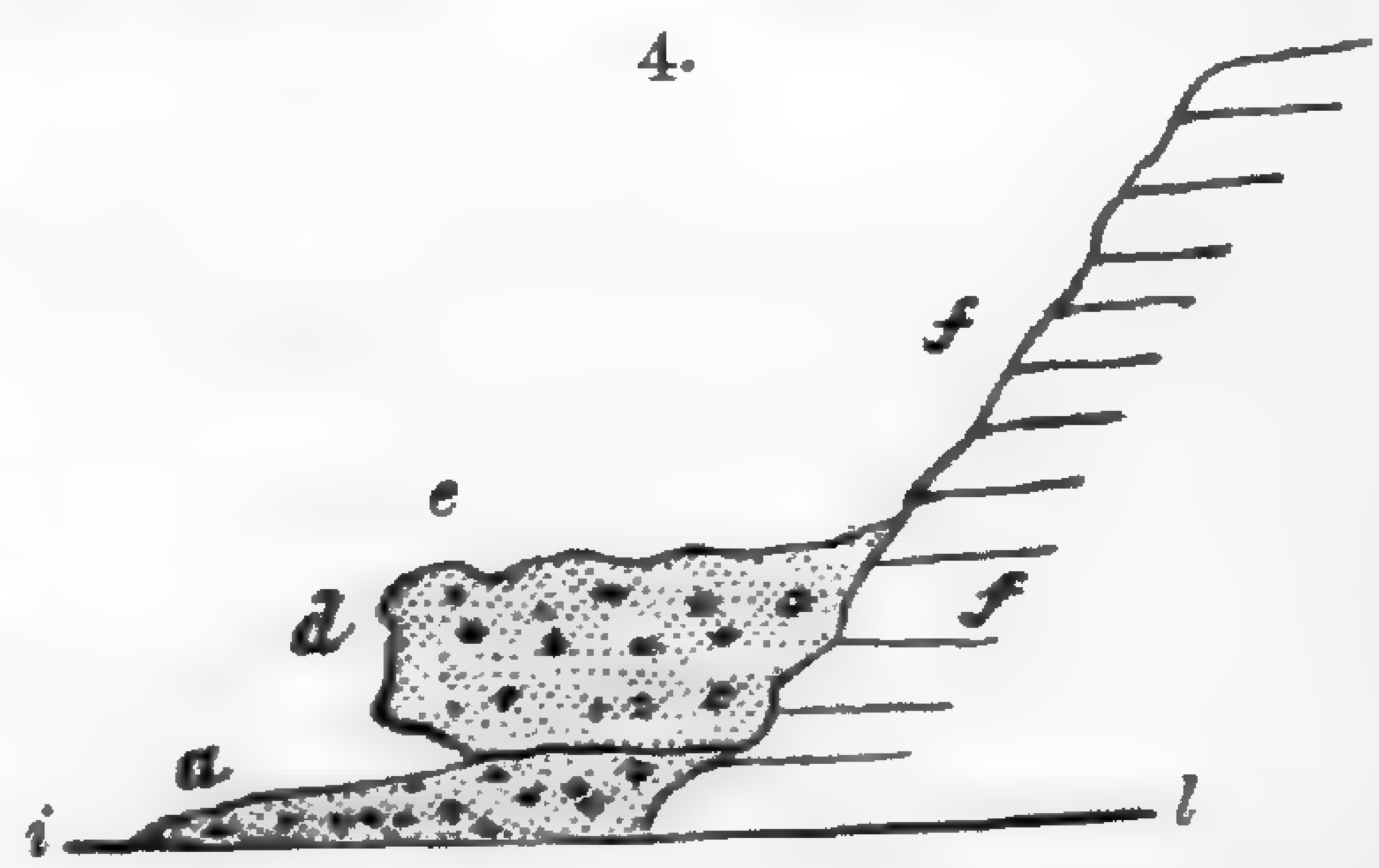
I have indicated these also in the figures. *The dark line, b, was certainly, therefore, an old forest-ground surface.*

3. Resting directly on this ground surface, and therefore enclosing the erect stumps, was a layer of stratified sandstone, *c*, two or three feet thick, filled with beautiful *impressions of leaves* of several kinds of forest trees, possibly of the very trees about whose silicified bases they are found. This layer is not continuous like the ground surface on which it rests.

4. Above this stratified leaf-bearing layer rests a coarse conglomerate, *d*, 100 feet thick, similar to the conglomerate *a*, but less coarse, and differing in being coarsely and irregularly stratified in places, *like modified drift;* in fact, undistinguishable from much of what is called northern drift except that it is partially cemented. Scattered about in the lower part of the conglomerate, *d*, and in the stratified sandstone, *c*, and sometimes lying on the dirt-bed, *b*, are fragments of trunks and branches of oaks and conifers, in a silicified or lignitized condition. They are evidently *silicified drift-wood.*

5. Above the conglomerate surface, *e*, and a little back from the river, rise the layers of lava, mostly columnar basalt, one above another, to a height, at this point, of 3,300 feet.

Such is a brief but accurate description of the cliff exposed by the Columbia River at the Cascades. My interpretation of these facts was then, as it is now, that the conglomerate *underlies* the lava, and, therefore, that the leaf-bed determines approximatively the age of the Cascade Range. But, as the actual contact of the basalt and the conglomerate was not then seen, subsequent reflection raised a slight doubt in my mind whether the conglomerate, instead of underlying, and therefore preceding the lava, may not be, in fact, a *subsequent river drift-deposit*—a bluff deposit—*overlying* the



asalt and concealing the lower portion of its face, as shown in the diagram, fig. 4. Which of these diagrams (fig. 3 or fig. 4) represent the true relation of the basalt and conglomerate? Before publishing anything on the subject, therefore, I determined first to settle this point definitely.

With this object I revisited the locality in August last; and after confirming my previous observations and collecting a number of fine leaf impressions and fragments of silicified wood, I went up the stream-beds of three of the creeks which run into the Columbia River at this point; one of them, Rock Creek, from the north, and two, Tanner's Creek and Deadman's

Creek, from the south. As these streams run at right angles to the course of the main river, they give *actual* sections somewhat similar to the *ideal* section, fig. 3. Moreover, as the stream-beds rise rapidly as we go up stream, I hoped to find in the stream-beds the actual contact of the basalt with the conglomerate. As we shall see, my hopes were completely realized.

The creek first ascended was Rock Creek. It runs in from the Washington side, near the upper steamboat landing. We had not gone far up the stream before we found the conglomerate, already described, forming the bed and cliffs of the stream. Petrified driftwood was found in abundance sticking in the conglomerate, and washed out and strewed in the course of the stream, thus becoming drift a second time. Some of these drifted fragments were of enormous size, trunks four feet in diameter, five to six feet long and many tons weight. A little farther up the gorge the stream falls perpendicularly about 150 feet, over the upper and more firmly cemented portion of the conglomerate, upon the softer portion of the same beneath. On one side of the ravine, just below the fall, is exposed an admirable section, showing the *basalt resting directly on the conglomerate.* In fig. 5 I give a rough sketch of this section, made on the spot. The perpendicular height of the section is about 200 feet.

5.

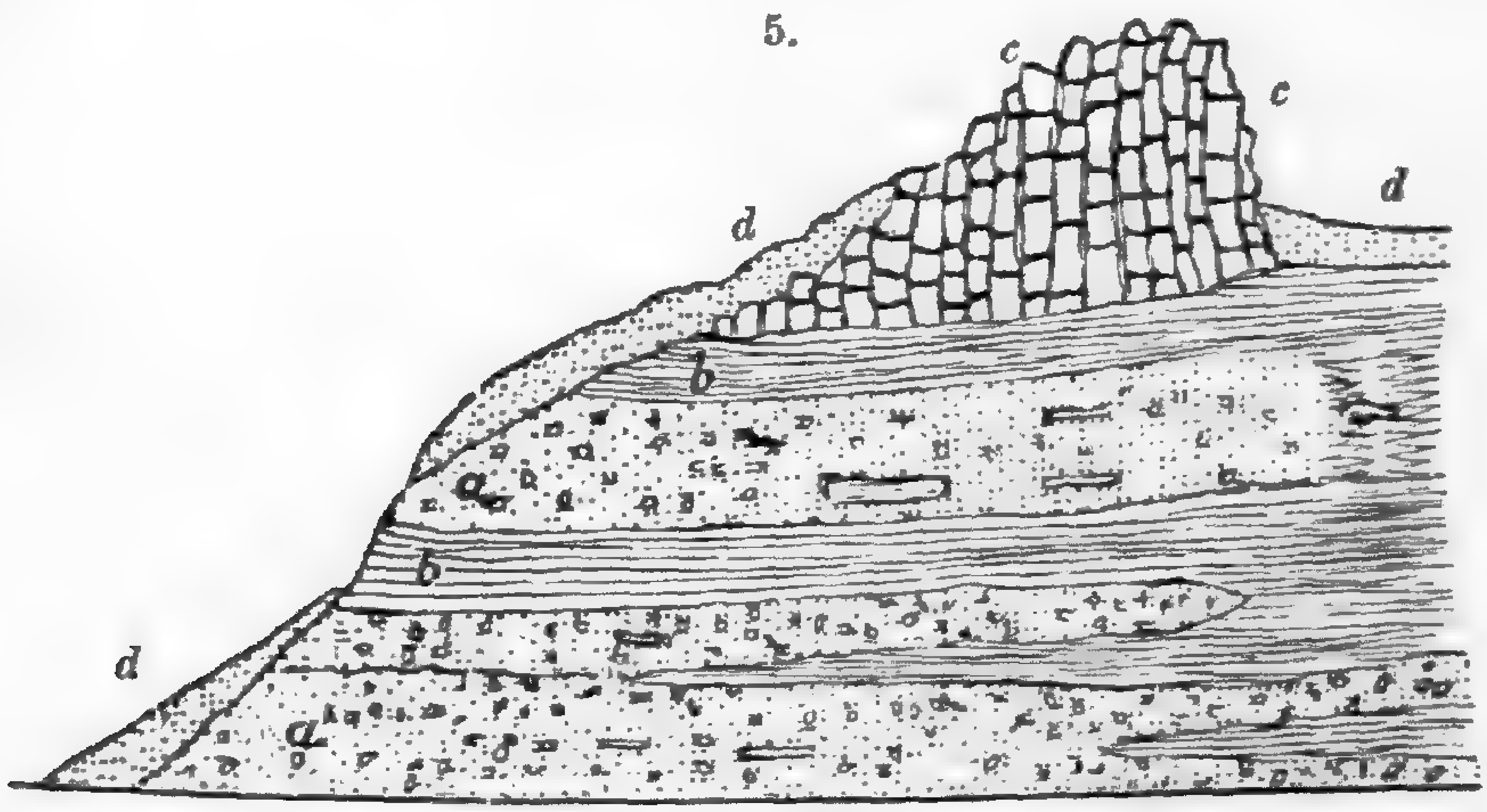
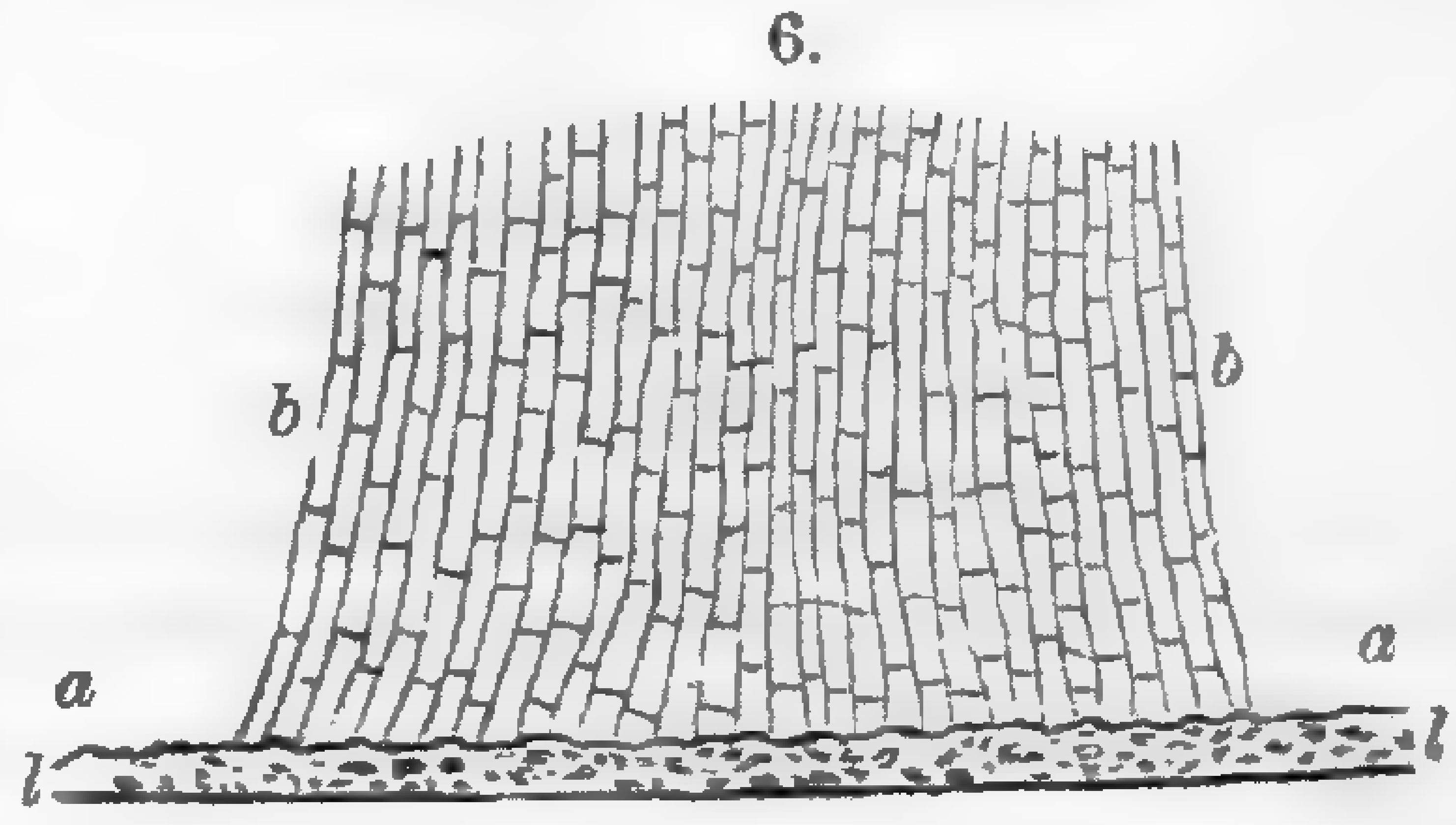


FIG. 5. *Cliff on Rock Creek.*—*a a*, pebble-conglomerate containing silicified driftwood; *b b*, stratified sands and clays; *c c*, irregularly columnar basalt; *d d*, superficial uncemented drift.

On the south or Oregon side, as already stated, we ascended two streams, but the most interesting was Tanner's Creek. This stream, for about three miles of its lower course, runs in a magnificent gorge, composed of conglomerate cliffs capped with towering summits of basalt. For some time the contact of these was not visible, being concealed by debris. But as the stream-bed rises the contact was approached, and finally reached about three miles from the river. At this point, the lower and deeper gorge is blocked by a perpendicular wall of basalt, over which the stream precipitates itself as a fall 250–300 feet high The gorge, the cliffs with their summits towering 3000 feet or more, the perpendicular basaltic wall, and the fall with its cloud of spray, the fresh greenness of ferns contrasted with the rich purple of rocks, together form one of the loveliest scenes I have ever looked upon. From the top of the falls runs back a less deep gorge, formed wholly of basalt. The same is true of all the streams which run into the Columbia River in this axial region of the Cascade Range: they run in lava gorges in the upper portion of their course, then fall over a perpendicular basaltic cliff on to the conglomerate beneath, and then finish their course in this latter rock. The verticality of the fall is evidently the result of the more rapid wearing of the softer underlying conglomerate, and is, therefore, itself a convincing proof of this relative position. But we are not left to inference on this point, for, in every stream-bed ascended, but especially in that of Tanner's Creek, *the actual contact was distinctly seen.* Evidently then fig. 3 represents truly the relation of the lava to the conglomerate.

After returning from the examination of Tanner's Creek, we found still another point where the junction is exposed by the Columbia River itself. Since the Columbia River shows the conglomerate on its south bank only for about two miles, it is evident that if the conglomerate underlies the lava and is exposed only by erosion, the point of junction must be reached by ascending the stream; and on the Oregon side, where the river washes against steep cliffs, ought to be visible. Walking up the abandoned railroad on this side, we found at *Tooth Bridge* what we sought. Here a perpendicular cliff of magnificently columnar basalt comes down directly into deep water of the river. At low water, i. e., in late summer, when we visited it, about three feet of the cliff next the water is composed of conglomerate, *a a*, fig. 6, and the long, slender, gently curved and very perfect basaltic columns, *b b*, are seen to *rest directly on the conglomerate.*

6.



Everywhere the general character of the conglomerate was found the same. Everywhere it is composed of rounded porphyritic pebbles and boulders of all sizes, in a more or less cemented earthy paste. In many places it was affected with irregular stratification, and in such cases it nearly always contained petrified drift wood. But erect stumps and leaf impressions, though diligently searched for, were found only at the locality first mentioned.

There is still another fact observed which has an important bearing upon the age of the lava-flow. Going up Tanner's Creek, the rising stream-bed reaches the upper surface of the conglomerate first about two miles from the main river. From this point, although the stream-bed continues to rise quite rapidly, the surface of the conglomerate again rises far more rapidly until it reaches a height of 200 *feet above the stream*, and then comes down again to the stream at the falls, where the contact is most clear. Again, at the point first examined (fig. 2), the upper surface of the conglomerate is 120 feet or more above the river, while it comes down to the water's edge at Tooth Bridge (fig. 6), a mile or two up the river, where the water surface is certainly but a few feet higher than at the lower point. I saw no evidence whatever of lifting or folding. It seems almost certain that the conglomerate surface upon which the lava was outpoured was a hilly land surface, made so by extensive erosion—*a second old ground surface.*

There can be no doubt, then, that the conglomerate really underlies the basalt for several miles from the river on either side. The line *b*, fig. 2 and 3, therefore marks an old forest-ground surface which antedates the Cascade lava-flow, and the silicified stumps are those of trees which grew on this ancient forest ground, and the leaves are leaves which fell possibly from these very trees, certainly from contemporaneous trees.

The order of events, as I conceive them, was briefly as follows: 1. The region of the Columbia River was a forest, probably a valley, overgrown with conifers and oaks. The subsoil of this forest was a coarse boulder drift. 2. By excess of water, either by floods or changes of level, the trees were killed, their leaves shed and buried in mud, and their trunks rotted to stumps. 3. Tumultuous and rapid deposit of coarse drift containing drift wood covered up the forest ground and the still remaining stumps, one hundred, perhaps several hundred feet deep. 4. The surface thus formed was eroded into hills and dales. 5. Then followed the outburst of lava in successive flows, perhaps for a long period of time, and the silicification of the wood and the cementation of the drift by the percolation of hot alkaline waters containing silica, as happens so commonly in sub-lava drifts. 6. Finally followed the process of erosion, by which the present stream-channels, whether main or tributary, have been cut to their present enormous depth.

In this last process of erosion the main river progressed more rapidly than the tributaries, and these latter, therefore, ran into the river on either side by foaming cascades, until the river had cut down into the underlying conglomerate. Then they commenced to work back as perpendicular falls, until they reached their present position. *The cascades of the Columbia River, as well as the perpendicular falls at the head of the deep side-cañons of the tributaries, have all been formed and their places determined by the cutting of these streams through the harder basalt into the softer underlying conglomerate.*

III. *Age of the Cascade Range.*

There has been hitherto much doubt as to the age of the Cascade Range. The Coast and Sierra Ranges, so distinct in middle California, become in northern California and southern Oregon blended and undistinguishable. In northern Oregon and in Washington, the two ranges become again quite distinct, the eastern and larger one being here called the Cascade Range. Orographic evidence therefore seem to indicate that the Cascades are a continuation of the Sierras and formed at the same time. But Whitney has shown * on paleontological evidence that, while the Sierras were formed at the end of the Jurassic, the Cascades in northern California have certainly been much disturbed and to some degree at least elevated, since the Cretaceous. Farther north, the stratified rocks of the Cascade Range are so deeply buried beneath the lava-flood, that it has been impossible hitherto to find stratigraphical or paleontological evidence of the age of the range. This evidence is, I believe, now for the first time furnished by my examination of the sections made by the Columbia River and its tributaries at the Cascades. *The sub-lava conglomerate, with its leaf-bed, furnishes the means of determining the probable age of the lava-flood, and, therefore, of the great mass of the Cascade Range.*

My first conclusions on this subject, in 1871, were, I now believe, erroneous. The fact that the lava flows of California, on the southern skirts of the great Cascade lava-flood, and some of the flows in the John Day Valley, on its extreme eastern skirts, are *underlaid by the latest Pliocene;* and the additional fact of the great resemblance of the sub-lava conglomerate of the Columbia River to the cemented sub-lava drift-gravels of California, led me, very naturally, but perhaps too hastily, to conclude that the great lava-flood took place and the Cascade Range was built up during the Post-Tertiary period; and I stated this as my view in my paper, "On the great features of the earth surface" † I now acknowledge my error. The paleontological evidence is the only certain one, and this is unmistakeably in favor of a greater age. I sent the box of leaves and petrified wood gathered from the leaf-bearing stra-

* See Geol. Surv. of Cal., vol. 1, p. 320 and seq.

† This Journal, vol. iv, p. 470.

tum, *c*, fig. 2 and 3, to Prof. Leo Lesquereux for examination. According to this high authority, they consist of leaves of two species of oak and one of conifer, and wood of oak and conifer. "The species," he writes me, "mark undoubtedly *Miocene or uppermost Eocene*, more probably the former."* Therefore I conclude the leaf-bearing stratum, *c*, fig. 2, is *certainly Tertiary and probably Miocene*; and, therefore, the lava flood occurred or *began* to occur during or after the Miocene. And since the upper surface of the conglomerate is itself an *eroded* land surface (p. 175), which erosion took place after the period of the leaf-bed, the lava-flood occurred more probably *after* the Miocene, i. e., *coincidently with the formation of the Coast chain.* I said "*began* to occur," for the process of up-building probably continued by successive fissure-flows, building higher and higher and extending farther and farther, until the Post-Tertiary; so that the skirts in John Day Valley and in California are newer than the lower part of the lava of the central region. When the fissure eruptions had finally ceased, the work was taken up by volcanoes, which have continued it nearly or quite up to the present epoch.

The Cascade Range throughout the whole region of the lava-flood, i. e., for at least 700 miles, is not more than an average of 5,000 feet high, although some volcanic peaks rise 11,300 (Mt. Hood), and even 14,400 feet (Mt. Shasta and Mt. Rainier). Now we have just seen that, of this 5,000 feet, nearly 4,000 feet consists of lava outpoured since the Miocene; and, moreover, that this lava extends in great thickness over a breadth of 100 miles. Evidently then the great bulk of this range is of late Tertiary origin. But it is not probable that the Cascade Range was born or first commenced to exist at this time. It is almost certain that it already existed as a low ridge of granite and slate like the Sierras, continuous with the latter and of the same age. The proof of this has not indeed been yet found in the middle Cascade region nor on the eastern flanks, for these parts are too deeply covered with lava. But on the western and especially on the southern borders of the great flood, where the lava thins out, first, occasional peaks of slate and granite appear as islands above the flood-level, and finally the flood itself dwindles into streams flowing about the bases of granite and auriferous slate hills similar to those characterizing the Sierra Range. It is true, the sections made by the Columbia River and its tributaries examined by me showed no slate or granite beneath the lava, but only Miocene conglomerate; and this conglomerate is made up, not of slate or granite boulders, showing the existence before the lava flood

* A description of these leaves will appear in the forthcoming volume on Fossil Botany of the Geol. Survey of California.

of slate or granite hills in the vicinity, but only of porphyry or porphyritic lava boulders; nevertheless, I think diligent search will yet find the evidences of slate and granite beneath the lava.* If the question is again asked, What then is the age of the Cascade Range and to what system does it belong? I answer: Like most mountain ranges, it was not formed at once. It probably first commenced as a continuation of the Sierra Range, and at the same time, viz: the end of the Jurassic; and this part belongs to the Sierra system. But its great bulk was formed at the end of the Miocene coincidently with the Coast Range; and this part may be said to belong, *so far as age is concerned*, to the Coast Range system.

IV. *Theory of the ejection of the lava-flood and of the formation of the Cascade Mountains.*

Over the surface of the lava-flood, especially along the crests of the Cascade Range, are scattered a number of extinct volcanic cones. From the Des Chutes plains is obtained a magnificent view of this range, from the Three Sisters on the south to Mt. Rainier on the north, a distance of over 200 miles. Along this extent are ten or twelve conspicuous snow-clad cones; many other smaller ones probably exist. Are these, then, the fountains from which flowed the great lava-flood? Has all this immense mass of fluid matter been ejected by the force of steam generated by the contact of percolating meteoric waters with incandescent subterranean fluid masses! It seems to me incredible: the effect is out of all proportion to the cause. It is only necessary to state the proposition in order to see its absurdity. Besides, the lava of the Columbia and Des Chutes Rivers is nearly all *perfectly solid*, entirely free from those vesicles so universal in lavas ejected by steam from craters. Only in the uppermost parts was there found any evidence in the structure of the lava of true volcanic action—any of the *boursouflée* condition so characteristic of true volcanic ejections. It is clearly impossible to account for the outflowing of such great floods of liquid matter except by more general causes affecting the whole earth—except by the action of those grand agencies by which mountain chains themselves are formed.

I have already, in a previous paper,† maintained that the interior contraction of the earth determines irresistible horizon-

* Newberry speaks of the cliffs of the Columbia River gorge (P. R. R. Surv., VI; Geology, p. 57) as composed of lava and *slate*. I have never seen anything but lava. Just above the Cascades, on both sides of the river, are seen slaty-looking mountains. I myself, at one time, thought they were slate. They are in fact phonolite. In the John Day Valley, indeed, I saw genuine slate hills with quartz veins, exposed by the erosion of the lava-flood; but these belong evidently to the Blue Mountains, not the Cascade Mountain system.

† This Journal, vol. iv, p. 345.

tal pressure of the crust on itself. I have also shown that mountain chains are the lines along which yielding to this pressure takes place; also that the yielding usually occurs along marginal sea-bottoms, giving rise to coast chains; and the reason why it occurs along these lines. I think, therefore, it will be now generally admitted that mountain ranges (Dana's Synclinoria) are certainly formed by a mashing together horizontally and an up-swelling vertically of lines of thick sediments along marginal sea-bottoms. Now in this mashing together, with foldings and consequent fissurings of the strata, it is easy to see that any sub-mountain liquid matter, whether preëxisting, or (as I think more probable) locally formed by the very act of crushing, *must be squeezed out.* It is in this way that I account for the great lava-flood of the Cascade and Blue Mountains. *The liquid matter has been squeezed out by the same force which elevated the mountain ranges;* by enormous horizontal pressure, determined by the interior contraction of the whole earth. Afterward, steam generated by meteoric waters percolating through the still hot erupted mass gave rise to volcanoes, which carried on the up-building process.

Thus much I have maintained in my previous paper. But Dana has recently* pointed an *inverse relation* between the amount of mountain mashings and foldings on the one hand and the amount of fissurings and fissure-eruptions on the other. This I believe to be a true principle. I wish, therefore, to illustrate and explain it.

Mountain ranges are *first* formed as already explained. But the ranges thus first formed, usually become *afterward* lines of *successive* elevation by lateral pressure. A mountain range, first *born of the sea*, continues to grow, more or less paroxysmally, by the same force which originally formed it. But there is this difference between the first formation and the subsequent increase. The first yielding of the soft sea-bottom sediments is comparatively quiet, with *little resistance*, and, therefore, produces *little heat* by the transformation of mechanical energy: it is a *gradual*, quiet mashing together, with folding of the strata and up-swelling of the surface into a mountain range, and the *metamorphism*, but *not fusion*, of the strata; while, on the contrary, the subsequent yielding of the already hardened land-surface takes place only after much resistance, and, therefore, with *much heat*, even to *fusion* of the strata, and also *paroxysmally*, with the fissuring of the strata and the *out-squeezing* of the sub-mountain liquid. In the first case, there is an actual elevation, by up-swelling or uplifting of the stratified surface to the whole extent of the height of the mountain: while in the second case, the increase of height is not so much by uplifting of

* Results of Earth's Contraction—part 4, Igneous Ejections. This Journal, vol. vi, p. 113.

the stratified surface, as by *up-building on* this surface, by the out-squeezing of liquid matter. In either case, however, whether by uplifting or by up-building. the actual increase of height would be precisely the same, being determined by the amount of lateral crushing.

Of course, these two modes of mountain-making may be combined in various proportions. We will now illustrate by examples.

The *Appalachian* chain was first formed and nearly completed at the end of the *Coal period*, by mashing, folding and up-swelling only, while its second but trifling increase at the end of the Jurassic was attended with fissure eruptions of considerable extent. The *Sierra Range* was first formed at the *end of the Jurassic*, by mashing together and up-swelling only; while its subsequent slight increase at the *end of the Tertiary* was attended with great fissure-eruptions. Similarly the *Coast Range* was formed by crushing together and up-swelling of its sediments at the *end of the Miocene*, while its great fissure eruptions did not take place until the *end of the Pliocene* or later. So, also, the Cascade Range was first born of the sea by horizontal mashing and vertical swelling, probably at the end of the Jurassic, though only as a low range, continuing the Sierra northward; its great subsequent increase took place at the end of the *Miocene*, by the outpouring of the great lava flood. Thus the Appalachian, the Sierra and the Coast Ranges were formed almost fully grown by the first method, while the Cascade Range was formed almost wholly by the second process. There are also of course some mountain ranges which are formed wholly by the first process, i. e., by successive upliftings without any eruptions at all.

The view which I have presented above in its main features is equally tenable, whether we regard the sub-mountain liquid as *locally formed* by the transformation of mechanical energy into heat, as maintained by Mallet and believed by me, or whether we regard it as a remnant of the *original sub-crust fire-sea* of Dana.

[To be continued.]

ART. XVIII.—*Analytical Notices;* by SAMUEL P. SADTLER, Ph.D., Prof. of Chemistry, etc., Pennsylvania College, Pa.

IN the number of this Journal for Feb., 1873, Dr. Wolcott Gibbs gives some miscellaneous analytical notices, and, among other things, speaks of a form of "ring-burner," which he commends to the attention of chemists generally as a useful piece of apparatus. I have had occasion within the last month to use this burner frequently in my laboratory, and have some few analytical results obtained by its use, which may be of general interest to working chemists.

My first use of the burner, however, dates back to the fall of 1869, when I was working in Dr. Gibbs' laboratory, on the double nitrites of cobalt and the alkali metals. I then used it constantly in determining the double sulphates of cobalt and potash or soda, and afterward the simple cobaltic sulphate. To my paper on these nitrites* I appended a few analytical notices, in which I spoke of the advantage of these methods of determination. One of my students having recently the determination of strontia to make, as a part of his analytical course, I had him determine it as strontic sulphate by the aid of the "ring-burner," and the results were so good, that I had the following series of experiments made to test the question of its applicability to sulphate determinations in several other cases.

The sulphates of the alkaline earths, barium, strontium, and calcium, are such stable compounds, and capable of standing such a high heat without decomposition, that they strike one at once as very suitable forms for the determination of these elements by evaporation with excess of sulphuric acid, in cases where the method by precipitation is not used. Accordingly, we find that the determination as sulphates by evaporation, of these three, is given by Fresenius, although not strongly recommended. Wöhler, in his "Mineral-Analyse,"† does recommend the determination of strontia and lime as sulphates. However, the evaporation of the excess of sulphuric acid over the ordinary forms of Bunsen-burner is so precarious an operation, as to effectually shut out these methods, except in case of necessity. With the "ring-burner," the evaporation of the excess of sulphuric acid is as safe as the evaporation of so much water over the water-bath.

Baryta.—Any of the compounds of baryta with volatile acids can, as Fresenius states, be determined as sulphate by evaporation with excess of sulphuric acid, and with the "ring-burner" rapidly and safely. I did not, however, make any quantitative determinations here, as the determination as sulphate by precipitation is so perfectly reliable and is generally applicable.

Strontia.—Here the determination as sulphate by precipitation is acknowledged to be of only tolerable accuracy, on account of the necessity of introducing the digestion with alcohol, and the subsequent washing with the same. The determination of sulphate by evaporation therefore, if accurate, would be of considerable importance. The results of some tests made by Mr. G. S. Eyster on this subject are as follows:

* This Journal, March, 1870.

† Mineral Analyses, 161, pp. 14 and 19.

A lot of crystallized strontic nitrate was taken, powdered, and dried at 100°.

·7345 grms. nitrate gave	·6348 grms. sulphate	=41·21 pr. ct. Sr.
·9840 " " "	·8505 " "	=41·21 pr. ct. Sr.

A second lot was re-crystallized, and large crystals were taken and dried between filter paper only.

·3007 grms. nitrate gave	·2594 grms. sulphate	=41·13 pr. ct. Sr.
·3641 " " "	·3133 " "	=41·03 pr. ct. Sr.

A third lot was then carefully dried between 100°–103°.

·3318 grms. nitrate gave	·2878 grms. sulphate	=41·36 pr. ct. Sr.
·3184 " " "	·2758 " "	=41·30 pr. ct. Sr.

The theoretical amount of Sr in $Sr(No_3)_2$ is 41·37 per cent. These results show very much greater accuracy than the determination of sulphate by precipitation, and there is no comparison as to the ease of manipulation and the rapidity with which the determination can be made.

Lime.—Here the determination as sulphate by precipitation is rarely used. as it is open to exactly the same objections as the process with strontia. However, we can precipitate lime as oxalate, and then weigh it as carbonate. after gentle ignition; or, if the quantity be not too large, as caustic, after lengthened exposure to the blast lamp, and the results are generally accurate.

However, it struck me that the sulphate determinations by evaporation were so accurate and so rapidly executed, that, instead of repeatedly igniting the oxalate with a piece of ammonic carbonate until a constant weight was obtained, we could convert the oxalate into sulphate, and run it down to dryness with the "ring-burner," with a great saving of time and labor. To test this, the following series of determinations with calcic oxalate was made by Mr. Edgar F. Smith at my request.

One lot of oxalate was prepared in the usual manner, washed on a filter and dried between 100°–105°.

·1860 grms. oxalate gave	·1725 grms. sulphate	=27·28 pr. ct. Ca.
·2083 " " "	·1939 " "	=27·38 pr. ct. "
·5013 " " "	·4659 " "	=27·33 pr. ct. "
·1944 " " "	·1808 " "	=27·35 pr. ct. "
·8097 " " "	·7517 " "	=27·31 pr. ct. "

Another preparation of oxalate was made and washed as before, and dried at 110°. Fresenius says that the oxalate does not part with its water until heated to 205°, but has the invariable composition $(C_2O_4)Ca+H_2O$. The results show, however, that it begins to lose water already at 110°.

·2195 grms. oxalate gave	·2051 grms. sulphate	=27·48 pr. ct. Ca.
·2432 " " "	·2272 " "	=27·48 pr. ct. "

A larger quantity was then precipitated and washed by decantation with boiling water, until, according to Bunsen's tables, the impurities remaining were reduced to $\frac{1}{100,000}$ in volume.

·7462 grms. oxalate gave	·6950 grms. sulphate		=27·39 pr. ct. Ca.
·7127 " " "	·6628 "	"	=27·35 pr. ct. "
·7592 " " "	·7073 "	"	=27·40 pr. ct. "
·8208 " " "	·7656 "	"	=27·43 pr. ct. "

The theoretical per cent of Ca in $C_2O_4(Ca)+H_2O$ is 27·40.

In some of this last preparation, two determinations of the amount of Ca were made by ignition over the blast-lamp and weighing as caustic lime.

·1207 grms. oxalate gave	·0463 grms. CaO	=27·40 pr. ct. Ca.
·1520 " " "	·0584 " "	=27·44 pr. ct. "

Finally, two portions of perfectly pure calcic carbonate, from a crystallized piece of calcite, that had been previously analyzed, and the composition of which was therefore known, were taken. After the precipitation of the lime as oxalate and drying on the filter, it was put in a weighed platinum crucible and the filter ash then added. The whole was then run down as sulphate with slight excess of sulphuric acid, with the aid of the "ring-burner." Only one analysis is given, as the other was spoiled in filtering the oxalate.

·9723 grms. $CaCo_3$ gave 1·3058 grms. sulphate =39·50 pr. ct. Ca.
39·50 per cent Ca corresponds to 55·30 per cent CaO.

Fresenius gives as the composition of "air dried $CaCO_3$," 55·51 per cent CaO, and in his determination of lime as sulphate, in experiment No. 67, obtained 55·31 per cent CaO.

The results given above, it is seen, are as accurate as are usually obtained in parallel determinations as carbonate, and the ease and rapidity of manipulation are very much greater.

There is yet another class of operations, in which I thought the "ring-burner" might be of assistance, viz: the processes involving oxidation with fuming nitric acid, which at present are rather tedious. I have not as yet, however, given it a careful enough trial to enable me to decide positively, either for or against it.

Antimony.—The conversion of antimonous sulphide into antimoniate of the teroxide of antimony, by the aid of fuming nitric acid is, as every chemist knows, very tedious, often proving a failure, on account of the fusing together of the separated sulphur. I tried whether the operation could be shortened by the use of the ring-burner. Antimonous sulphide, dried on the filter, was taken, placed in a porcelain crucible, and after being moistened with a few drops of dilute acid, was covered well with fuming nitric acid. The heat of the ring-burner was then applied, very gradually, to the upper rim of the crucible. Several times the oxidation was very successful, leaving only the white Sb_2O_8. On the other hand, in several tests, a globule of sulphur formed, which could not be gotten rid of, until the last heating. In no case, however, was there any loss from spurting. I then tried two analyses of tartar emetic, which I give here. In the first a globule of sulphur remained, and I had to drive it off at last by heat, giving of course considerable loss. In the other the sulphur was completely oxidized.

·3115 grms. tartar em. gave ·1294 grms. Sb_2O_8 =32·91 pr. ct. Sb.
·3206 " " " " ·1451 " " " =35·86 pr. ct. "

The formula $C_4O_6H_4K(SbO)+\frac{1}{2}H_2O$ gives 36·53 per cent Sb.

I have given these two tests for what they are worth. They do not allow me to recommend the use of the "ring-burner" here; but, if I can obtain better results on farther trial, the neatness and ease of the manipulation will recommend it.

Lead.—I also made some tests on the rapid conversion of plumbic sulphide into plumbic sulphate, but at present I have no quantitative results, and the qualitative results are not complete yet. I think, however, it promises well.

With regard to the "ring-burner" itself, I have little to say, as Dr. Gibbs speaks sufficiently explicitly about it. Of course it is best run with a water-blast or "water-tromp." I have, however, to run it with the bellows of the glass-blowing table, as I have no hydrant-water in my laboratory. This greatly increases the labor of the processes. With the constant blast it needs no attention whatever, after being regulated.

Gettysburg, Dec. 24th, 1873.

ART. XIX.—*On the Oxidation of Alcohol and Ether by Ozone;* by Prof. A. W. WRIGHT.

IT has been stated by Houzeau,* that alcohol exposed to the action of ozone is instantly oxidized, with the formation of aldehyde, acetic acid, and hydrogen peroxide, and that ether, under similar conditions, undergoes an analogous change, being even more rapidly oxidized, with the production of hydrogen peroxide. It does not appear, however, that either the conditions of the action of ozone on these substances, or the nature of the compounds formed, have been much further studied. With a view to determine some of these points, and especially to ascertain whether ozone could be advantageously used in the production of acetic acid from alcohol, an ex-

* Comptes Rendus, lxxv, p. 142, 1872.

tended series of experiments was made by the writer, the results of some of which are here given.

As ozone is easily resolved into ordinary oxygen by heat, it appeared probable that its action would be intensified by submitting the substances examined to its influence at a somewhat elevated temperature. In the first experiments accordingly, either the alcohol was itself heated, or its vapor was subjected to the action of heat in conjunction with the ozone. In later experiments alcohol at the ordinary temperature was used, both absolute, and mixed with varying quantities of water. The ozone was produced by passing dry oxygen through an ozonizing tube under the influence of electricity. In some of the experiments Houzeau's apparatus for this purpose was employed; in others that described by the writer in a former number of this Journal, used with statical electricity. All the connections of the parts of the apparatus traversed by ozone were made with glass tubes united with perforated corks which had been soaked in melted paraffine. The determinations of the amount of acid were made volumetrically, by means of a solution of caustic potash in distilled water, and the percentages given in the results express the proportion of acid obtained relatively to commercial acetic acid, with which the comparisons were made. As the latter contains about 25 per cent of anhydrous acid, a sufficiently near approximation to the absolute percentage of acetic acid would be obtained by dividing the results by four. In all cases the amounts obtained were very small. Commercial alcohol, which contained about 8·5 per cent of water, was used in the experiments numbered 1 to 5. The volume of liquid used in each case was 100 cubic centimeters.

1. In this experiment vapor of alcohol was passed into a flask kept at 100° C., by means of a water-bath, and ozonized oxygen driven slowly through the same flask. The mixture of gas and vapor was then conducted into another flask immersed in cold water, where the alcohol and products of oxidation were condensed. The operation was continued for one hour. The alcohol at the beginning was found neutral, but at the end of the experiment it gave a decided acid reaction. The percentage relatively to commercial acetic acid, that is, the strength of the dilute acid, as compared with the former, was 1·62 per cent.

2. Ozone and alcohol vapor were passed through a porcelain tube heated to a temperature of 200° or 250° C. Percentage obtained 0·81, of which but a portion was acetic acid, as the reaction was evidently different from that at a lower temperature, and other products were formed.

3. A small quantity of alcohol was placed in a large flask, and ozone passed into it at intervals, the flask being frequently

shaken vigorously. This was continued for ten or twelve hours. The percentage obtained was 3·17, or if reduced to the amount for one hour, about 0·32.

4. Ozone was passed through boiling alcohol, and the vapor condensed in a cool flask. Percentage 1·18.

5. Ozone was passed through boiling alcohol in a flask provided with a vertical condenser, by which the condensed liquid was returned to the flask, and thus repeatedly subjected to the action of the gas. Percentage 1·22.

6. In the following series of experiments alcohol was employed which had been mixed with quick-lime, and after standing several days was then distilled off. It contained less than two per cent of water. Four determinations were made, with alcohol alone, and with alcohol mixed with different proportions of distilled water. The liquid was maintained at the boiling point during the whole operation, a vertical condenser being used, as in the preceding experiment. The results are given in the following tables, in which the first and second columns give the relative amounts of the alcohol and distilled water in the mixtures, the third shows the actual percentage of acid obtained, the fourth the amounts corresponding to equal portions of alcohol, and the fifth those amounts divided by four, giving the approximate absolute percentage.

The numbers are reduced, to correspond to a continuance of each experiment one hour.

Alcohol.	Water.	Percentage in mixture.	Percentage in alcohol.	Percentage absolute.
100	0	0·55	0·55	0·14
50	50	1·66	3·32	0·83
10	9	0·93	9·30	2·32
5	95	1·66	33·20	8·30

7. The experiments in this series were made in the same way as the preceding, except that the alcohol was not heated, and the results are as follows:—

Alcohol.	Water.	Percentage in mixture.	Percentage in alcohol.	Percentage absolute.
100	0	0·59	0·59	0·15
50	50	0·34	0·68	0·17
10	90	0·08	0·80	0·20
5	95	0·09	1·80	0·45

In the determinations it was assumed that the acid obtained was acetic acid. This would be justifiable in all cases except those where the alcohol was highly heated, as, though a small quantity of formic acid is produced, shown by its action on nitrate of silver and otherwise, acetic acid constitutes the chief portion of the product. When a quantity of the liquid was neutralized with the potash solution, evaporated, and the residue treated with dilute sulphuric acid, a strong odor of acetic acid was given off. The products of the experiment in which the alcohol was highly heated were examined in the same way, but the odor was hardly to be recognized as that of acetic acid, having some resemblance to that of formic and butyric compounds.

Although the results are not perfectly concordant, as was to be expected, considering the varying conditions of some of the cases, and the feeble proportion of acid abtained, they agree in the main very well, and show clearly enough that the action of the ozone is influenced very materially by the presence of water, and by heat.

The table in No. 7 shows that as water is added to the alcohol, the total amount of acid produced decreases, but less rapidly than the alcohol, so that with each addition to the percentage of water a larger percentage of alcohol is acidified. Both this and the preceding table show that the increase is more rapid as the proportion of alcohol becomes small.

In No. 6, with the exception of the first case, in which the amount of acid is not greatly different from that of the first in No. 7, the numbers show a large increase in the total amount of acid, and a still greater increase relatively to the proportion of alcohol. This was due in part to the fact that, by the arrangement of the apparatus, the hot vapor was mingled with the ozone, and thus more thoroughly exposed to its action. A comparison of the results in Nos. 1 and 4, however, shows that it is to be attributed chiefly to the higher temperature. It will be seen also that the effect is more strongly marked, the greater the proportion of the water. In the fourth experiment of No. 6, about eight per cent of the alcohol was converted into acetic acid, being the highest proportion obtained.

It would be of interest to determine, if possible, the nature of the reaction by which the alcohol is acidified. As considerable quantities of aldehyde and hydrogen peroxide are always produced, it seems most probable that the action proceeds in the manner commonly assumed, namely, by the abstraction of two hydrogen atoms from the alcohol molecule, forming aldehyde, and hydrogen peroxide, together with water. The aldehyde would, in part, be immediately oxidized by the ozone, and in part by the gradual action of hydrogen peroxide. This action would be greatly facilitated by heat, which decomposes both ozone and hydrogen peroxide. If the reaction is less simple, and the alcohol molecule is broken up, we might expect to obtain carbon di-oxide as one of the products. A special experiment with alcohol which was not heated, though continued for nearly two hours, showed that, if any, only a very small amount is eliminated.

It may be observed that the proportion of alcohol in the third and fourth cases of Nos. 6 and 7, is not very different from that in the wines and other liquors used in the manufacture of vinegar. Although the application of ozone for this purpose, by the methods followed in these experiments, would be neither practicable nor economical, it is not improbable that operations on a larger scale might give better results. Especially in the German or "quick" vinegar process, where a large surface is exposed, and a considerable rise of temperature is experienced, it is hardly doubtful that the process would be materially accelerated by passing ozonized air through the apparatus, and to accomplish this an ozonizer of moderate capacity would be sufficient.

Experiments similar to those above described were made with ether and ozone. The oxygen employed was dried by passing it through a wash-bottle containing strong sulphuric acid, and thence through a large U-tube filled with small fragments of pumice-stone freshly saturated with the concentrated acid. The oxygen, after passing from this through the ozonizer, was conveyed into a flask containing the ether, and bubbled from the extremity of a glass tube immersed in the liquid. Energetic action at once took place. Each bubble of the gas gave a little cloud as it broke at the surface, and the liquid in a few minutes lost its transparency and became opalescent. This effect was caused by the production of a liquid not miscible with the ether, and dispersed through it in very minute globules. After a time they gradually fell to the bottom of the flask, and coalesced, first into drops, and finally to a thin stratum of liquid.

After the operation had been continued for an hour or more, the heavy liquid was examined, portions of it being removed with a thin glass tube. It was found to be strongly acid, and when tested, by neutralizing it with potash solution, evaporating, and treating with dilute sulphuric acid, gave an unmistakable odor of acetic acid.

Tested with lime-water, and otherwise, the liquid gave evidence of the presence of a considerable proportion of oxalic acid, while its behavior with nitrate of silver and with ferric chloride indicated a small amount of formic acid.

A small quantity of manganese di-oxide was washed with distilled water and placed in a narrow test-tube. When a little of the liquid was dropped upon this, copious bubbles of gas were given off, doubtless oxygen, though in too small quantity to be tested. With ether (containing no hydrogen peroxide) and chromic acid the liquid produced an intense blue color. It also immediately discharged the color of indigo-solution. These tests indicate the presence of a large percentage of hydrogen peroxide. Aldehyde also appeared to be indicated, though with less certainty than the other substances. The liquid then was apparently water, formed partly by the action of the ozone and partly by the condensation in the cold ether of traces of moisture left in the gas after passing the drying apparatus, and holding in solution the other products of the reaction, namely, hydrogen peroxide, acetic, oxalic, and formic acids, and probably aldehyde.

Yale College, Jan. 21, 1874.

ART. XX.—*Notes on some of the Fossils figured in the recently-issued Fifth volume of the Illinois State Geological Report;* by F. B. MEEK.

As stated by Prof. Worthen in a prefatory note to the paleontological part of the above mentioned volume, we had intended, not only to revise and extend the previously published descriptions of some of our own species, before sending the text of this volume to the press, but also to add full descriptions, with remarks on the affinities of all the forms illustrated on the accompanying plates, including many species that had been described by others from far inferior specimens to those contained in the splendid collections at our command.

Ill health, however, and other unavoidable circumstances, prevented the accomplishment of this design, and rendered it necessary merely to repeat the previously published descriptions of our own species, without modification, and to give references only to the original descriptions of forms described by others, often from quite imperfect material. Fortunately the descriptions of our own species were originally pretty fully written out, as published in a series of papers in the Proceedings of the Academy of Natural Sciences at Philadelphia some years back, and generally require little modification. With the aid, however, of the unrivaled collections that we had for study, particularly those of the *Crinoidea*, mainly from Mr. Wachsmuth's collections, we could have added much information to all that was previously known in regard to the old species, the original descriptions of which are merely cited without note or comments in the text.

Although the figures we have given, and the rather full explanations accompanying each plate, will, it is hoped, enable the intelligent paleontologist to understand and appreciate the new information added to this department of science by these illustrations, some additional notes in regard to the many interesting types figured will doubtless be of service to students in using the volume. Of course, however, it will be readily understood that such notes prepared (here in Florida) without any of the type specimens, and but few of the numerous works of reference at hand, must necessarily be incomplete. I will, however, proceed to refer to such of the species figured as may seem to require some farther explanations, mentioning them in the order in which the figures occur on the plates, rather than with regard to natural arrangement, or to their relative positions in the text, as follows:

Actinocrinites sculptilis Hall; plate IV, fig. 2.—This form was originally figured and described by Prof. Hall, in the Iowa Report, from specimens showing only the body up to the base of the free rays. In a former volume of the Illinois Reports, we called attention to the very peculiar character of the free rays, and the equally unusual arrangement of the arms along the side of these rays, in this type; and the figure cited above was given to illustrate this character more fully. By reference to this figure, portions of two of these rays will be seen extending out, one on each side, and bearing pinnule-like appendages along their sides. These free rays, however, are not properly arms, as this term is usually applied in descriptions of the fossil Crinoidea, with open ambulacral furrows above, but rather, as it were, extensions of the body, as they are composed, on the dorsal or under side, of a direct continuation of each radial series of pieces: while on the upper or ventral side, they are each covered over by a series of fixed pieces, corresponding in all respects with those forming the vault of the body, from which they extend out continuously. This covering over of these free arm-like rays gives them the character of tubes, along each side of which there are small openings for the connection of the smaller lateral appendages seen in the figure.*

These smaller appendages, however, are not pinnulæ, as they would at a first glance seem to be, but really correspond in all respects to the true arms in all the other types of the *Actinocrinites* groups; and, as has been determined by the examination of other specimens, bear the true pinnulæ, or tentacles as they are sometimes called, along their inner margins.

Another species, as first shown by us in a former volume of the Illinois Reports, has the same peculiar arrangement of the arms along tubular free rays; but in this these free rays bifur-

* The structure of the bases of these arms is not well shown in the engraving.

cate once, the divisions being long, straight, apparently rigid, and support the true arms along each side. For the group including the species presenting these remarkable tubular extensions bearing the true arms, we have, in some of our papers, and in a former volume of the Illinois Reports, proposed the name *Steganocrinus*.

In this connection, it is worthy of note, that we now know species which, in the same way, agree precisely in all other respects with *Platycrinites*, that present exactly the same kind of radial extensions, having the true arms arranged in the same way along their sides. For this type I have proposed the name *Eucladocrinus*, in Dr. Hayden's Report of the U. S. Geological Survey of the Territories for 1871, page 378. Whether the groups of species presenting these peculiar characters should be viewed as subgenera under *Actinocrinites* and *Platycrinites*, or as separate and distinct genera, there may and doubtless will be differences of opinion, depending on the peculiar views of authors in regard to what should constitute generic, and what less important distinctions, among such animals.

Taxocrinus Thiemei Hall; plate IV, fig. 1.—Although this beautiful crinoid seems to differ in some of its minor details of structure from *Forbesiocrinus Thiemei* Hall, it is the form referred to that species by the collectors at Burlington, where the typical *F. Theimei* was well known.* It would not, however, properly fall into the group *Forbesiocrinus*, whether we regard that as constituting a distinct genus, or as only a subgenus under *Taxocrinus*. These two groups shade into each other by so many gradations, however, that it is not possible to divide the numerous species now known into two sharply defined *genera ;* as was shown by us in the Proceedings of the Academy of Natural Science in 1865, page 183, where we referred the species *Thiemei* to the older genus *Taxocrinus*.

The great development and protuberance of the upper radial pieces in this crinoid, and the probably consequent drawing together of the parts above, give it a peculiar physiognomy, not seen in the typical *Taxocrinus* or *Forbesiocrinus*. Still it seems to show no differences of structure upon which it can be separated generically; while, in the small number of its anals and interradials (the only point of difference between *Taxocrinus* and *Forbesiocrinus*), it agrees *much* more nearly with *Taxocrinus*, as may be seen by comparing it with *Forbesiocrinus Wortheni*, plate XIV, fig. 2, and plate XV, fig. 7,† which is a typical *Forbe-*

* If I remember correctly, *F. Thiemei* was described as being without either anal or interradial pieces. Smaller specimens, however, believed to be the young of the form we have figured, have been found, that were nearly or quite destitute of interradial pieces, and seemed to agree exactly with the description of *F. Thiemei*.

† The specimen from which these two figures were drawn was found loose, and was evidently water-worn, so as to have lost its surface granules.

siocrinus, with the anal and interradial spaces filled by numerous pieces. The differences between both of these types and the allied group *Onychocrinus* will also be apparent by comparing them with *O. exculptus* L. & C., plate XIV, fig. 4.

Batocrinus pyriformis Shumard ; pl. V, figs. 5*a*, *b*, *c*.—The original typical specimen of this species consisted of the body only, without the arms or ventral tube. Our figures, however, also illustrate, for the first time, the arms, a portion of the column and most of the ventral tube or proboscis. At the time our figures were drawn, and the explanations of the plate were prepared, the very fine specimen represented by figure 5*a* was fastened on a board, with the ventral tube made out by adjusting together several pieces, so as to include, with an intermediate piece, the terminal portion represented by fig. 5*c*. Misunderstanding Mr. Wachsmuth, to whom the specimen belonged, when he stated that the pieces of the tube, as adjusted together, were all known to belong to the same *species*, I left him with the impression that they were known all to belong to this individual *specimen*.

On subsequently inquiring more particularly about this, Mr. Wachsmuth, with his usual conscientiousness and candor, informed me that the upper pieces of the tube, as made out, although certainly known to belong to the same *species*, did not belong to this individual *specimen*. He assured me, however, that, on first seeing this specimen, as found embedded in the rock, the tube was as long as restored by him ; but that, in detaching it from the matrix, this appendage broke, and some of the terminal pieces were lost among the loose rocks at the quarry, so that he afterward replaced the lost parts from another individual of this species.

On receiving Mr. Wachsmuth's letter containing this information, I struck out of the figure, on one of the proofs of the plate, the portion of the tube connecting figures 5*a* and 5*c*,* so as to leave the latter detached ; but as I did not afterward see the explanations of the plate, the necessary correction there was unintentionally overlooked, and Mr. Wachsmuth thus wrongly made responsible for the assertion that the detached portions of the tube figured were known all to belong to the same individual specimen.

I mention the above facts, because, if the terminal part of the tube replaced from another specimen belonged to a *smaller individual*, it would necessarily make the extremity relatively too much attenuated, and the opening proportionally too small

Actinocrinites delicatus M. and W ; plate VIII, fig. 2.—Since describing this little crinoid under the above name, Mr. Wachs-

*** It may be proper to explain here, that, when plates or figures are mentioned in these notes, unless otherwise stated, they always refer to the Illinois Report under consideration.**

muth has informed me that he has discovered at Burlington a series of specimens of intermediate sizes, that show it to be only the young or undeveloped condition of one of the large species of *Strotocrinus;* but, not having his letter at hand, I cannot say which. He states that, as it advanced in growth, the upper interradial, interaxillary and interbrachial pieces, with the overlying vault plates, were gradually developed, and, with the supraradial and brachial pieces, spread out so as to cause the remarkable dilation of the upper parts of the body and vault, so characteristic of the adult *Strotocrinus.* If so—and Mr. Wachsmuth's unequaled opportunities for observation, as well as his well known carefulness as an observer, render his opinion on such a point worthy of no little consideration—it would be a fact of much interest, since it would show that *Strotocrinus,* at one of the earlier stages of its growth, presents exactly the characters of *Actinocrinites.* This, however, would not necessarily prove the two types to be generically or subgenerically identical, since there are many examples, in various departments of natural history, in which two clearly distinct, but allied, genera agree in all essential generic characters, in their young state, until they advance to a certain stage of growth, which, in one, becomes its fixed adult condition; while the other goes on to develop the additional distinguishing characters. It would show, however, that *Strotocrinus* holds a higher position in the scale of development than *Actinocrinites.*

Looking at the figures only, without having the specimens at hand for farther study, it would seem to me quite as probable that our *Actinocrinites penicillus* (fig. 2* of the same plate cited above) may be a young *Strotocrinus.* We doubtless have much to learn yet in regard to the development of the fossil Crinoidea that will gradually come to light as more and more extensive collections accumulate; possibly to modify, to some extent, the prevalent views in regard to their classification.

(To be continued.)

Art. XXI.—*On the Connection between Isomorphism, Molecular Weight and Physiological Action;* by James Blake, M.D.

Having been engaged for many years in investigating the action of substances when introduced directly into the veins or arteries of living animals, I have obtained some results which I consider are of interest under a purely chemical point of view. In the following table the substances experimented with have been arranged in groups according to their physiological action, and after the name of each substance is the quantity required to be injected into the veins or arteries in order to arrest, in the course of a few minutes, the reactions between the different solids and fluids of the body which constitute life. These reactions are arrested in the same manner by all the substances contained in the same group; but in a distinct and totally different manner by substances contained in different groups. This is not the place to dwell on the physiological phenomena that have been observed. Details of many of my experiments will be found in the 3d, 4th, 5th and 7th volumes of the Journal of Anatomy and Physiology.

Note.—I have appended to each group a statement of the more marked physiological reactions that characterize the substances it contains.

GROUP 1.

Lithic sulphate,	2·56	Impede pulmonary circulation. Kill by their action on the lungs; do not affect the irritability of the heart.
Sodic nitrate,	1·30	
Rubidium chloride,	0·25	
Thallic sulphate,	0·20	Render the blood more fluid. Do not affect nervous system except Cs.
Cæsium chloride,	0·55	Do not impede systemic circulation except Ag.
Silver nitrate,	0·12	

GROUP 2.

Magnesic sulphate,	6·40	Do not affect the pulmonary or systemic circulation.
Ferrous sulphate,	2·24	
Manganous sulphate,	1·00	Exert a marked action on nervous system.
Nickel sulphate,	1·20	
Cobalt sulphate,	1·30	Arrest the action of the heart. Prevent the coagulation of the blood except Mg.
Copper sulphate,	1·20	
Zinc sulphate,	1·30	
Cadmium sulphate,	0·60	

GROUP 3.

Nitrate beryllium,	0·65	Impede the systemic and pulmonary circulation.
Sulphate alumina,	0·68	
Yttria nitrate,	0·25	Heart not affected.
Cerium chloride,	0·22	Blood coagulates firmly.
Ferric sulphate,	0·19	

GROUP 4.

Calcium chloride,	3·28	No effect on systemic or pulmonary circulation except Pb. Ventricles of heart paralyzed. Contraction of voluntary muscles after death.
Strontium nitrate,	2·64	
Barium chloride,	0·32	
Lead acetate,	0.76	

GROUP 5.

Palladium chloride,	0·064	Act on the heart.
Platinum chloride,	0·120	Render respiration intermitted. Impede systemic circulation. Change the physical properties of the blood.
Kalium chloride,	0·120	
Ammonium Iridium chloride,	0·064	

GROUP 6.

Ammonia nitrate,	3·00	Paralyze the heart. Impede systemic circulation. Favor the coagulation of the blood and cause convulsions.
Kalium nitrate,	0·33	

GROUP 7.

*Chlorhydric acid,	0·46	Impede systemic and pulmonary circulation. Increase the irritability of the heart (ventricles). Kill by arresting the respiration.
*Iodhydric acid,	0·62	
Bromic acid,	0·75	
Iodic acid,	1·00	

GROUP 8.

Phosphoric acid,	4·00	No well marked physiological effects in large quantities. Kill by arresting pulmonary circulation.
Arsenic acid,	4·00	
Antimony tartrate,	2·70	

GROUP 9.

Sulphuric acid,	1·7	Impede pulmonary circulation. Act on the nervous system.
Selenic acid,	1·4	

A simple inspection of the above table† will suffice to show the facts which have led me to submit these remarks to the Chemical Society, viz: the connection between isomorphism and physiological action of the compounds of the metals and metalloids, when they are introduced directly into the blood, and also amongst the more purely metallic elements, the general increase in the intensity of the physiological action of the bodies in each isomorphous group, as the atomic weight of the electro-positive element of the compound increases. The connection of physiological action with isomorphism, I published more than thirty years ago, in a paper read before the Royal Society in June, 1841, and subsequent investigations have confirmed the truth of the statement I then made. I was led to investigate the connection between the physiological activity of a substance and its atomic weight by a communication made by Dr. Rabuteau to the Academie des Sciences in 1869, in which it was stated that "the metals are more active physiologically according as their atomic weights are more elevated." A review of my experiments plainly showed that this was not the case; for instance, beryllium, with an atomic weight of 9 is far more poisonous than strontium with an atomic weight of 87; but the facts I had observed plainly show that in the case of the more purely metallic elements the physiological activity

* Injected into the arteries.

† The numbers contained in the above table can but be approximative, as must be the case in operating with a substance of such uncertain properties, as living matter subject to variations which in the present state of science we are unable to detect. The manner in which the experiments were performed was not calculated to furnish accurate data as to the smallest quantity of the different substances that would destroy life. After one or two preliminary experiments to ascertain the general physiological action of a substance, and the quantities in which it could be used, the experiments recorded were made by injecting the substance into the veins or arteries, in quantities sufficient to produce the physiological effects, but not so as to destroy life until three or four injections had been made. It is the sum of the quantities so used in all the experiments recorded that have furnished the numbers in the table, reduced, however, to the same weight of animal (for dogs 7 kilo., for rabbits 1·4 kilo.; rabbits were only used in the first group. As the experiments were all made in the same manner, the numbers thus obtained are fairly comparable.)

in the same isomorphous group generally increases with the atomic weight. For instance, in the first group, the relative physiological activity between the compounds of Li and K is 125 : 1 ; in the 2d group, between Mg and Cd 104 : 1 ; in the 3d group, between Be and Fe 3 : 1 ; in the 4th group, between Ca and Ba 10 : 1. In the 5th group, the quantities used were so small, and in the case of Pt and Ir double salts had to be used, so that the numbers representing the relative physiological activity hardly admit of comparison. In the whole group, there is great physiological activity combined with high atomic weight. In the metalloids this connection between physiological activity and atomic weight does not exist, although the particular reactions caused by each group is still dependent on their isomorphous relations, as closely as in the case of the true metals.

The only well marked exceptions that have been met with to the analogous action of isomorphous elements are in the salts of potash and ammonia. Both these substances differ entirely in their action from the other bodies in the soda group. I am aware that the isomorphism of soda and potash has been called in question by some chemists, and it certainly does not fit into the soda group, by the relative increase of its specific weight with its atomic weight. As regards the salts of ammonia, they are also totally distinct in their action from the salts of the soda group, resembling to a certain extent many of the organic poisons by their action on the nervous system. The salts of silver and of lead also differ in some respects in their physiological action from the other substances of the group to which they belong. They both give rise to the well marked reactions characterizing each group, yet they both produce certain effects on the capillary circulation in which they resemble each other, but in which they differ from other members of the group in which each is placed. Cæsium also differs from the other members of the first group by its action on the nervous system.* With these exceptions the substances contained in the same group agree with each other, in the effects they produce on the pulmonary and systemic circulation in their action on the heart, and on the nervous and muscular systems, and in the physical changes they give rise to in the blood. In the present imperfect state of our knowledge as regards the isomorphous relations of the elements, it would be useless to speculate on the nature of the changes induced on living matter by different groups of isomorphous substances.

These changes must be quite different from those occurring in ordinary chemical reactions, as in these reactions the greater

* It will be seen on referring to the table that these three substances present the most striking anomalies as to the connection of physiological intensity with increased atomic weight.

the atomic weight of a substance, the larger the quantity required to produce analogous chemical changes, whereas in these physiological reactions the reverse of this is the case. They would appear to be more closely connected with the phenomena of dissociation than with any other chemical process. Whatever the nature of these changes may be, they are evidently connected with the molecular constitution of the compound, as in the ferrous and ferric salt not only is the intensity of the physiological action increased by the change from a bivalent to a quadrivalent molecule, but the nature of the action is completely altered. The most important deductions from these experiments are—

1. In the changes induced in living matter by inorganic compounds, the character of the change depends more on the physical properties of the reagent than on its more purely chemical properties.

2. That the character of the changes is determined by the isomorphous relations of the electro-positive element of the reagent.*

3. That among the compounds of the more purely metallic elements, the quantity of substances in the same isomorphous group required to produce analogous changes in living matter, is less as the atomic weight of the electro-positive element increases.

4. That the action of inorganic compounds on living matter appears not to be connected with the changes they produce in the proximate elements of the solids and fluids, when no longer forming part of a living body, at least in so far as our present means of research enable us to judge.

5. That in living matter we possess a reagent capable of aiding us in our investigations on the molecular properties of substances.

San Francisco, California, Dec. 1st, 1873.

ART. XXII.—*On the Dissociation of certain Compounds at very low Temperatures*; by A. R. LEEDS, Prof. Chemistry, Stevens Institute of Technology.

IT has been shown by Fittig† that ammonic chloride, when in solution in water, is decomposed by boiling. H. C. Debbits‡ has recently investigated other salts of ammonia, especially the nitrate, sulphate, oxalate and acetate, and has found that all of

* In a memoir read before the Academie des Sciences, Paris, in June, 1839, I proved that on injecting saline solutions directly into the blood, this physiological action was determined by the electro-positive element of the compound being but little influenced by the acid with which it was combined.

† Ann. Chem. Pharm., cxxviii, s. 189. ‡ Ber. der Deutsch. Chem. Gesell., v, p. 820.

these liberate ammonia, not only when their solutions are boiled, but also, in case a current of pure hydrogen is passed through their saturated solutions, at the ordinary temperatures and even at 0° C. This latter observation is a confirmation of what was stated previously by M. Gernez,* that when an inert gas like hydrogen or nitrogen is passed through a salt in solution or in the fused condition, it causes the liberation of a certain constant quantity of that one of the constituents which is volatile at the temperature of the experiment. This is true of the hydrosulphates, the bisulphites, the biacetates and the bicarbonates, a solution of potassic bicarbonate "even at ten degrees liberating increasing quantities of carbonic acid." In like manner the nitrates may be made to set free a portion of the acid at temperatures far below those which are ordinarily regarded as their decomposing points.

The object of the present investigation is to establish:—

1st That it is not necessary to change the atmosphere in coutact with the particles of the salt held in solution, by passing a current of an inert gas, in order to induce dissociation at temperatures below the boiling point.

2d. That there is a certain fixed temperature, which is different in the various salts, at which the dissociated constituent can be detected and recognized by sufficiently delicate tests.

3d. That it is highly probable that the dissociation of these salts in solution is analogous to the evaporation of the solvent, and that while it arrives at a maximum, under ordinary atmospheric pressures, at the boiling points of their saturated solutions, yet it takes place in a diminishing proportion at much lower temperatures, in some cases even below their freezing points.

The reagent employed in these experiments was alizarin, an alcoholic solution of which will readily detect one part of soda in three million of water, and a correspondingly small amount of potash, ammonia, etc. The apparatus consisted of a small flask, closed by a cork through which a delicate thermometer was passed with its bulb immersed below the surface of the liquid. A short tube entering the neck of the flask at right angles, contained a coil of alizarin paper, dry and carefully supported out of contact with any moisture which might condense on the sides of the tube. The results of the experiments are given in the following table, Bar. 29·84—29·82 in.

The temperature of the solutions at the beginning of the experiments was 17°–20° C., and the increase was conducted very gradually and slowly, about a half hour being required for each determination. The alkaline reaction was made evident by a quick and sharp transition from yellow to red of the alizarin paper at the temperatures indicated. In the case of

* Comptes Rendus, lxiv, p. 606.

ammonic chloride it would at first appear that there was a progressively slow increase of the point of sensible dissociation with the dilution of the liquid, but this was probably owing to the extreme slowness with which the liberated ammonia from a very dilute solution diffused itself, rendering it difficult not to overstep the temperature actually requisite.

Liquid.	Reaction of Liquid.	Parts in 100.	Temp.	Mean.	Reaction of Vapor.
Ammonic Chloride,	Feebly acid.	10·60	37° C.	37°	Strongly alkaline.
" "	"	"	37°		" "
" "	"	5·30	38°	38°·5	Alkaline.
" "	"	"	39°		" "
" "		2·65	39°		" "
" "		"	40°	39°·3	Feebly alkaline.
" "		"	39°		" "
" "		1·325	39° 39°		" "
" "		"	39° 41°	39°·2	" "
" "		"	38° 39°		" "
Ammonic Sulphate,	Acid.	45·62	50°	50°·5	Alkaline.
" "	"	"	51°		"
" "	"	22·81	51°	51°·	"
" "	"	"	51°		"
" "		11·40	50°·5	50°·5	Faintly alkaline.
" "		"	50°·5		" "
Ammonic Oxalate.	Strongly alk.	Saturated.	−1°	−1°	Strongly alkaline.
" "		at 7°·5 C.	−1°		
Ammonic Acetate.	Acid.	Saturated.	55°	55°	Alkaline.
		at 17° C.	55°		"

The ammonic oxalate was surrounded by a freezing mixture, and when the mass was frozen, an alkaline reaction was obtained almost immediately on inserting the coil in the exit tube. The atmosphere surrounding the apparatus in this experiment was likewise below the freezing point. It is probable that the point of sensible dissociation was much lower than that observed.

Finally, this point of sensible dissociation depends on the circumstances of the experiment, and the delicacy of the apparatus and reagents employed in its detection. For when a thermometer and a coil of paper supported at the distance of 3^{mm} from the surface of the liquid were placed in a sealed flask containing the ammonic chloride solution employed in the first experiments, tabulated above, it was reddened at the expiration of an hour, the temperature being 20°, and when the flask was previously exhaused of air, at 17° C. The lower temperature in the last case was probably due to the rising of air bubbles into the vacuum above the liquid. The temperatures of sensible dissociation above given are not to be regarded therefore as absolute, but as relative and valuable only as indicative of the comparative dissociability of these salts when in aqueous solution.

Stevens Institute, Jan. 19th, 1874.

ART. XXIII.—*On the Influence of Color upon Reduction by Light;* by M. CAREY LEA, Philadelphia.

IN all metallic salts which suffer reduction by exposure to light, the facility of reduction varies with the acid to which the base is united. Thus in the case of iron, ferric oxalate and citrate are much more easily reduced than ferric sulphate. Further, the reducibility of any salt is generally much influenced by substances placed in contact with it. Thus silver chloride exposed to light alone, changes somewhat slowly to a violet color; in contact with silver nitrate it changes more rapidly and assumes a deeper color; and if, in addition, we place certain sorts of organic matter in contact with it, the change is still more rapid and an intense black color may result. Pure silver iodide, as I have shown elsewhere, undergoes no chemical decomposition when exposed, completely isolated, to the sun, but in contact with silver nitrate, and also with many other substances, it is extremely impressible. The sensitiveness to light of silver bromide also is greatly modified by substances placed in contact with it.

As respects silver bromide, a new and interesting view has been recently published by Dr. Herrman Vogel. He affirms that substances placed in contact with silver bromide do not merely affect its general sensitiveness to light, but also modify its impressibility by rays of different refrangibilities, so that spectra impressed on a silver bromide surface will not merely vary in general intensity, by changing the accelerating substance placed in contact with the bromide, but that the relative intensities of different portions of the spectrum will also change. That the change, moreover, will follow a certain law, to wit: that colored substances absorbing certain rays will increase the impressibility of the bromide to those rays which they absorb. Thus a colored substance (itself capable of uniting with bromine) which absorbs the yellow rays and radiates the rest of the spectrum, will increase the sensitiveness of silver bromide to the yellow ray. Dr. Vogel even affirms that he can render silver bromide as sensitive to the yellow ray as to the violet.

It seemed therefore a matter of interest to determine whether any general law existed that when a metallic compound capable of reduction by light was placed in contact with a body capable of being oxidized (or of uniting with Cl, Br or I, as the case may be), the capacity of reduction of the metallic compound by any particular portion of the spectrum would be influenced by the *color* of the body placed in contact with it. If, for instance, a ferric salt be placed in contact with an oxidizable body of well marked color, will the reducibility of the ferric salt by particular rays be modified? And if so, will it follow the law announced by Dr. Vogel for silver bromide, that the sensibility of the reducible compound will be exalted to those rays which are absorbed by the body placed in contact with it?

To solve this question, I have made an extended series of experiments. But I have not been able to verify the existence of such a law. The results which I have obtained are briefly as follows:

Ferric Salts.

Ammonia ferric oxalate was selected as the most easily reducible of the ferric salts. To obtain accurate results with it, however, much care is needed in its preparation. It is necessary that it should be prepared entirely in the cold: if any heat is used to aid the solution of the ferric oxide in ammonia binoxalate, I find that there is danger of reduction and the product may contain ferrous salt, even a trace of which renders it unsuitable for use. Freshly precipitated, and still moist, ferric hydrate, if left in contact with a solution of ammonia binoxalate for about a week at ordinary temperatures, gives a pure product free from ferrous salt.

Strips of paper were first strongly colored with aurine, with aniline blue and aniline green; they were then impregnated with the ferric salt, and were exposed to light side by side with ordinary white paper similarly impregnated with the ferric salt.

The exposure of these and of all the following preparations was managed in the following manner. Colored glass was obtained of shades corresponding as nearly as possible with the colors of the spectrum. Violet and green glass could be found in commerce of suitable shades. The other colors were obtained by dissolving suitable transparent pigments in varnish and coating glass with it. With the aid of aniline colors and colorless varnish, the most brilliant shades were obtained, with a perfect transparency. These glasses were next cut into strips ten inches long and five-eighths wide and arranged to form a sort of artificial spectrum, under which papers of different preparation could be simultaneously exposed. It is evident that in some respects this mode of operating is less advantageous than that of exposure to a real spectrum. But this disadvantage is compensated by the possibility afforded of a most accurate comparison of the effects of the various substances, inasmuch as the different papers can all be exposed simultaneously and all receive precisely the same impression. There results an accuracy of comparison which can perhaps be obtained in no other way.

The papers prepared with ferric salt alone, and also those with ferric salt in contact with the colors named, were simultaneously exposed. They were then plunged into solution of ferridcyanide of potassium, which renders evident whatever reduction has taken place by the production of Turnbull's blue, the unreduced portions remaining white.

Result.—The series of experiments was carefully repeated three times. The aniline blue was found to be entirely without influence; the printed spectrum obtained corresponded in every respect with that of the plain ferric salt. The aniline green slightly diminished the impressibility, but not more in one part than another. Aurine produced this effect still more strongly.

Neither coloring matter exerted any specific influence on the impressibility by any particular portion of the spectrum.

Other coloring matters were tried without results of special interest, except that a cold aqueous extract of *safflower* (carthamus) much heightened the sensitiveness to the whole spectrum, perhaps doubling it. But this increase extended, as it was judged, equally to all the rays.

Potassium Bichromate.

In contact with *aurine*, potassium bichromate exhibited no change of action in its behavior to white blue or violet light, nor in the orange or red. But in the yellow it was distinctly less impressed than in the plain bichromate band.

The papers colored with aniline blue and green behaved like the plain bichromate, except that they were perhaps a little less sensitive to the whole spectrum. These results, including that with aurine, were obtained alike whether the exposure to light was short or long.

Potassium Ferridcyanide.

Papers colored with aurine, coralline, aniline red, blue and green, and with mauveine were exposed. The reduction was first brought out with ferric ammonia alum. The influence of that substance in darkening and setting the aniline colors was found very objectionable, and little could be learned from the bands so obtained. Ferric ammonia oxalate was then substituted with excellent results.

All of the six colors above mentioned acted by diminishing the impressibility of the ferrid-cyanide, so that the printed spectra obtained were all weaker than that of the plain ferridcyanide paper used for comparison. But the weakening was general throughout the range of the spectrum, and no relation could be traced as existing between the color used and the impression made by particular rays.

Rosaniline and aniline green weakened the sensitiveness very slightly, almost imperceptibly; mauveine and coralline much more, aurine and blue most of all.

The reduction undergone by potassium ferridcyanide may also be rendered evident by exposing the paper to the action of uranic nitrate, which strikes a deep red-brown with the ferrocyanide and a yellowish color with the unchanged ferridcyanide. A complete series of papers examined in this way showed that all the colors tried, rosaniline, mauveine, aniline green, aniline blue, coralline and aurine, diminished the facility of reduction at the less refrangible half of the spectrum, and most of all the blue and coralline. As respect the more refrangible half of the spectrum, all the colors acted injuriously, and each to about the same extent.

When ammonia ferric oxalate is mixed with potassium ferridcyanide in solution, and exposed to light, a violet color results which, by simply plunging into water, passes to a rich blue. As the action where these two substances are exposed together is somewhat different from that which takes place when one only is exposed and the other is applied subsequently, a series of papers was prepared with the two salts mixed, and combined with the colors already mentioned.

None of the six colors tried increased the impressibility of the sensitive papers to any ray of the spectrum, but the coralline, aurine and blue diminished the sensitiveness to the entire range of rays from red to violet. The green diminished the sensitiveness to the less refrangible end rather more than to the more refrangible end, and the rosaniline and mauveine produced scarcely any observable effect whatever.

A separate series of trials was made to test the effect of the colors on the impression of violet light as compared with white light, by giving much shorter exposures than in the preceding experiments. If coloring matters as such have any influence on the susceptibility to the action of particular rays, then a range of six colors extending from violet blue to deep red ought in some cases to favor the action of the violet, in others to interfere with it. But after very careful and repeated trials, it was found that all the colors lowered the sensitiveness to both violet and white, to both equally, and with all the colors to about the same extent.

Uranic Nitrate.

The same range of coloring matters were tried with uranic nitrate, the extent of reduction being made evident by the subsequent application of potassium ferridcyanide, which with uranous nitrate gives a burnt sienna colored precipitate.

The first series was tried with short exposures to violet and to white light only. In this case the mauveine appeared to give a slight increase of sensitiveness, but as this extended equally to white and to violet, no conclusion as to influence on specific rays could be drawn. The aniline green, blue and rosaniline diminished the general sensitiveness a little, the coralline a good deal, and the aurine nearly destroyed it.

Under the influence of the entire spectrum the following results were obtained.

Red and orange rays. Mauveine same as plain uranium salt; other colors less sensitive.

Yellow. Rosaniline same as plain uranium salt; other colors less sensitive.

Green and blue. All the colors less sensitive.

Violet. Mauveine same as plain uranium salt; all the rest less sensitive.

These effects are evidently not capable of being reduced to any general law.

Silver Chloride.

A number of experiments led to the following results:

Coralline increased the sensitiveness to all the rays, but especially to blue and violet, in which the increase is very considerable.

Rosaniline increased the sensitiveness to blue and violet, but diminished all the rest.

Aniline blue diminished sensitiveness to green, increased it to yellow, and was without effect on the rest.

Aurine diminished sensitiveness to all.

Mauveine and aniline green were without effect.

Litmus reddened by acetic acid strongly increased the sensitiveness to the blue and violet, and somewhat diminished it to the red and orange.

Here we have three red colors increasing the sensitiveness to the blue and violet. But one, coralline, increases the sensitiveness at the red end also, whereas red litmus and rosaniline diminish the sensitiveness at the red end.

Silver Iodide.

The character of the action of light to be investigated in the case of silver iodide and silver bromide differs essentially from that involved in the foregoing cases. In the cases examined up to this point, the reducing action was completed in the exposure, although this effect was in most instances only rendered evident by a double decomposition effected subsequently. But with silver iodide and bromide, light is only permitted to act for a brief space of time, and subsequently a strong image is built up upon this faint or invisible image by the precipitation of silver through the agency of gallic acid or other reducing agent, thus producing a true "development." It is with these images developed by gallic acid that we shall have to do in this and the following section.

Silver iodide papers, imbued with various coloring matters and containing free silver nitrate, were exposed to the different rays with the following results:

Red and orange rays. None of the coloring matters tried increased the sensitiveness to these rays.

Yellow rays. Aniline blue and green increased the sensitiveness to these rays somewhat, mauveine perhaps a very little. Coralline diminished the sensitiveness a little, aurine and rosaniline a good deal.

Green rays The aniline green (a bluish green) increased the sensitiveness to the green ray somewhat, aniline blue (a violet blue) increased it a very little. Mauveine was without influence, whilst coralline aurine and rosaniline gave weaker results than the plain iodide paper, the last two much weaker.

Blue rays. Aniline green is here again the strongest. Blue and mauveine increased the sensitiveness to the blue rays a little, coralline was without effect, aurine and rosaniline diminished the sensitiveness.

Violet rays. Aniline blue, green and mauveine all considerably increased the sensitiveness, coralline increased it a little, aurine and rosaniline diminished it a little. With ordinary white light the order of sensitiveness was the same as in the violet rays.

It does not appear that there exists any general law connecting the color of the substance placed in contact with the silver iodide, with increased or diminished sensitiveness to particular rays. A violet blue aniline color increased the sensitiveness to the yellow and green rays, but also had a similar effect upon the violet rays. Aniline green increased the sensitiveness to the violet, blue, green and yellow rays, but not to the orange and red; its tendency was to increase the sensitiveness of colors approximating to its own color, whereas coralline increased the sensitiveness to the rays which most differed from its own color.

Silver Bromide.

Silver bromide is at once the most important of all the sensitive substances known, and the most difficult as to the exact determination of its reactions, so much do these vary from very slight causes. Multiplied experiments were consequently made; thirty-five complete spectra were obtained, besides prints from detached portions of the spectrum. Below I give the substances in the order of the greatest sensibility which they conferred, beginning with those that gave the greatest.

Substances which conferred the greatest sensibility to the more refrangible half of the spectrum.	Substances which conferred the greatest sensibility to the less refrangible half of the spectrum.
Infusion of tea leaves,	Salicine,
Salicine,	———
Red litmus,	Plain bromide,
Coralline,	———
Aniline blue,	Aniline green,
———	Mauveine,
Plain bromide,	Aniline blue,
———	Aurine,
Anil. green,	Infusion of tea leaves,
Mauveine,	Coralline,
Aurine,	Infusion of capsicum,
Cold infusion of safflower,	Cold infusion of safflower (carthamus).
Infusion of capsicum.	

The substances above the "plain bromide" increased its sensitiveness, those below it diminished it, and in all cases to an extent corresponding with the order of rank in the respective columns.

In the above lists it will be noticed that there are not only colored, but also colorless and nearly colorless substances. After having made a number of experiments with silver bromide, I inclined to the opinion that the influence of the various matters placed in contact with it might have very little to do with their colors and might depend upon properties independent of color. To verify this, substances having either no color, or very little, but known to me from previous experiments to act powerfully on silver bromide, were experimented on. These were salicine, infusion of tea and infusion of capsicum; the first entirely colorless, the two last imparting to the sensitive paper only a faint neutral coloration. My expectation was verified; no substance tried exerted a more powerful discriminating action on the sensitiveness to individual rays than salicine, which substance rendered the silver bromide as sensitive to the red ray as to the green.

Generally speaking, the substances enumerated above exerted very much the same effect on the different colors at each end of the spectrum, that is, those that heightened or impaired the sensitiveness to the green acted similarly on the yellow, orange and red, and those that heightened or impaired the sensitiveness to the violet rays acted similarly to the blue rays and also to white light. The few interesting exceptions noticed were:

Red litmus (litmus reddened by the least possible quantity of acetic acid) and *coralline* produced an exceptional insensitiveness to the green rays.

Salicine conferred on silver bromide a remarkable sensitiveness to the red and orange rays, so that the whole of the less refrangible rays from green to red produced about an equal impression. A repetition of the experiment with a shorter exposure gave the same curious result, the most curious of all the results attained.

Carthamus, red litmus and *capsicum* produced an exceptional insensitiveness to the red and orange rays.

No trouble was spared in these experiments to obtain accurate results. In each set to be compared with each other, each paper was floated or immersed, as the case might be, for an exactly equal time on or in solutions of exactly equal strength. As papers when hung up to dry are always more strongly imbued with the soluble matters at the lower end, care was taken in the successive treatments which each paper received to dry it with the same end uppermost, and in the exposure to light, to keep all the papers with their least sensitive ends to the same end of the spectrum: without this last precaution no concordant or reliable results could have been obtained.

The conclusions which I have reached seem to me to establish that there is no general law connecting the color of a substance with the greater or less sensitiveness which it brings to any silver haloid for any particular ray. At the same time, I do not consider that these results necessarily contradict or disprove the very different results obtained by Dr. Vogel. They, however, show that Dr. Vogel's results cannot be generalized. The explanation of the discordance may lie in the different conditions of the experiment. Dr. Vogel worked with silver bromide contained in a collodion film and combined with other substances not known (commercial bromide plates made by a secret formula). These substances may have themselves powerfully affected the properties of the silver bromide. Collodion certainly does; the reactions of silver bromide formed in the body of a pure paper differ from those which it exhibits when formed in a collodion film, probably because the collodion is made some time in advance and is always more or less decomposed by the alkaline bromides, which are dissolved in it. I am inclined to believe that the comparative indications which are obtained by the use of paper as a medium are more reliable than those obtained with collodion, because it is difficult if not impossible to make several collodion films in succession having equal thickness. And as the amount of impressibility to any given light or any given ray of light increases in proportion to the thickness of the film, it follows that in comparing two plates that have undergone different treatments, we are liable to ascribe to the treatment results that may depend only on the different thicknesses of the films. Whereas paper we can always obtain of uniform thickness, so that with equal immersion in solutions of equal strength, we are sure that the papers are equally charged with the substances to be tested.

ART XXIV.—*Note on Lignite Beds and their Under-clays;* by
E. W. HILGARD, University of Michigan.

IN the January number of this Journal, Mr. Lesquereux defends his view of the origin of the lignite beds of the Rocky Mountain region, against supposed objections thus formulated by him:

1. That the lignite beds are of too small extent, or cover too limited areas, to have been formed otherwise than by the heaping of materials carried into small basins.

2. That the under-clays of the lignite beds contain no roots.

Having had extensive opportunities of observing lignite beds, from the Cretaceous to the Quaternary strata, in the States of Mississippi and Louisiana, I would add a few remarks to those of Mr. Lesquereux.

As regards the first point, I am altogether unable to see its force. Were the bays and marshes of the Louisiana coast region, or some portions of the Mississippi bottom, so depressed as to be covered over with deposit, and their peaty contents compressed into lignite, there would result just such a multitude of basin-shaped masses, from a few yards to many square miles in extent, and of variable thickness, as we now find in the Eocene lignitic formations on the Gulf border. The analogy goes even so far, that much of the lignite of those formations is obviously formed, not by any coöperation of the usual peat mosses, but altogether out of rushes and reeds, such as nowadays dispute the ground, in the coast marshes, with the Sabal, Cypress, Myrica, etc. In some cases, a semi-fluid peaty mass fills these smaller basins to a depth of 10 to 15 feet; in these, of course, as Mr. Lesquereux remarks, larger trees cannot grow. But the Cypress, Myrica, and even the *Magnolia glauca*, adapt themselves to this condition of things by sending out long taproots into the bottom clay, while their nutrition is performed by a crown of fibrous roots near the surface. Thus anchored, they may readily be swayed sideways in the soft mass, in every direction; but are difficult to pull up, although, under such circumstances, their size rarely exceeds a few feet.

These facts, as well as the well-known ability of the Cypress and Tupelo to exist and flourish in water maintaining some depth throughout the year, led me to consider the possible causes of the apparent absence of vestiges of roots from the under-clays of lignite beds, which early attracted my attention.

In the extensive marsh at the mouth of Pearl River, a solid clay, resembling very much the under-clays of lignite beds, or the bottom clays of Cypress swamps, is deposited for some distance on both sides of the river channel. The whole surface is covered by a dense growth of tall "round rush" (*Scirpus lacus-*

tris), whose roots form a dense, matted mass, over a foot in thickness, covering the clay soil, but penetrating it very little. Nevertheless, as the successive annual overflows raise the level of the clay deposit, the roots and root-stocks necessarily become imbedded in it, and one would expect to find their remains, or more or less distinct impressions, in the mass of the soil. Such, however, is the case only close to its surface, to the depth of a few inches at most. Lower down, we find only indistinct indications of the previous existence of vegetable forms, in a kind of cellular structure; and at the depth of a foot or more even this vanishes, and we have a solid blue or brownish clay, as free from organic remains or impressions as any under-clay of lignite beds, yet obviously of the same origin as the soil proper, above.

The same thing, precisely, may be observed in sections of Cypress swamps, both ancient and modern, on the Mississippi, Arkansas and Red River. Even where the Cypress stumps are perfectly preserved, their roots are often seen to terminate at a short distance, in rather an abrupt point of heart-wood; and beyond, their course is scarcely, or not at all, traceable in the solid clay.

The cause of this complete obliteration of spongy roots or spongy parts of roots is doubtless to be sought in the oxidizing influence of ferruginous solutions percolating from above, and the subsequent action of pressure upon the yielding mass.

In the more or less definitely porous under-clays of the coast marshes, the cavities are almost throughout lined with a green or yellowish-green, semi-gelatinous film of what, on exposure to air, becomes a plainly visible coat of iron rust. In the Cypress swamp under-clays such a film may often be seen to form the inside lining of a cavity still possessing the shape of a root, with, perhaps, a free central core of lignitic matter still existing, out of contact with the walls. And the original course of roots may often, but not always, be traced by that of a thin, vein-like ferruginous film, completely flattened out, so as to escape ordinary observation. If, by a subsequent process of reduction and solution, this film were also to be removed, not a trace of the original root would remain.

Again, the peculiarly "massy" cleavage of these under-clays is not only very often marked by minute films of (sometimes almost red) hydroferric oxide, but, on close examination, they frequently exhibit a multitude of minute "slickensides," proving the occurrence in the mass of internal movements, doubtless resulting from compression. That similar clays exhibit, at Petite Anse and other points, a glacier-like motion down hill, I have elsewhere* stated.

It appears to me that in these two agencies combined we

* Smithsonian Contr. Knowl., No. 248, p. 18.

have an adequate explanation of the apparent absence of organic remains from many under-clays, not only of lignites, but also of Paleozoic coal beds. That the leaching process which deprived the coal beds of all the ash ingredients necessary to vegetation, has also been instrumental in the removal of iron and organic matter from the Carboniferous fire-clays, has been often suggested; but the efficacy of the process, when combined with pressure, to obliterate all traces of the softer parts of plants and animals, imbedded in clays, has hardly been sufficiently dwelt upon. That another phase of the same agencies has been instrumental in obliterating the teeming fauna of the Port Hudson beds, whose character can now be studied only in a few limited localities, I have already shown.* And there can be little doubt that the absolute dearth of organic remains which has thus far frustrated all my attempts to gain a definite clue to the age of the "Grand Gulf" beds of the Gulf border, is largely due to the same cause, and not to the conversion of the Mexican Gulf into a "Dead Sea" during the Post-Eocene Tertiary period.

Lignite beds composed of drifted materials are not rare in the Gulf border, from the lowest Cretaceous beds to those of the Champlain era. But they are usually very much localized, and consist mainly of driftwood, which is not only over- and underlaid by sandy materials, but also intermixed with them. Beds of compact lignite underlaid to any great extent by sand, are quite exceptional.

Art. XXV.—*On recent Deep-Sea Dredging operations in the Gulf of St. Lawrence;* by J. F. Whiteaves.

During the summer of 1873, the Hon. the Minister of Marine and Fisheries of the Dominion of Canada very kindly placed one of the government schooners at my disposal, for dredging purposes. These investigations, which were undertaken on behalf of the Natural History Society of Montreal, had, as their primary object, an examination into the present condition of the Marine Fisheries of the Gulf, and were supplementary to similar explorations carried out by myself in the summers of 1871 and 1872. In the present paper, a short descriptive account will be attempted of some of the most interesting zoölogical specimens collected in 1873. Nearly nine weeks were spent at sea (from July 18th to September 8th); and during this time, although the weather was often unfavorable, we nevertheless got about seventy successful hauls of the dredge. The cruises were essentially four in number, but on the whole the first yielded the greatest number of novelties.

* Smithsonian Contr. Knowl., No. 248, p. 12.

Cruise 1.—The first two weeks were devoted to an examination of the deep water in the center of the mouth of the river, between Anticosti and the Gaspé Peninsula. The most interesting specimens were obtained in from 200 to 220 fathoms, mud; and among them are the following:

FORAMINIFERA.—*Marginulina spinosa* M. Sars; a large *Triloculina* allied to *T. tricarinata*, perhaps *T. cryptella* D'Orb.; curious arenaceous forms, new to me, some of which are simple and unbranched, others widely triradiate, and a third series are irregularly cruciform, and even five and six-rayed. They are all, most likely, forms of one species; but whether they are the *Asterorhiza limicola* of Sandahl or not, I have at present no means of ascertaining.

SPONGES.—One specimen of *Trichostemma hemisphæricum* M. Sars; one of *Cladorhiza abyssicola* M. Sars; and about a dozen of the *Hyalonema longissimum*, of the same author, were taken in 220 fathoms. With these occurred another species, which is either a true *Tethea*, or belongs to a closely allied genus. In shape it is more or less pyriform, somewhat triangular in section, and with a flattened base. There are three orifices, corresponding to the three angles, of which two are basal. These are connected on two sides by a perforated canal or tube. The front basal orifice is partly closed by an outer fine open network and an inner and coarser one of siliceous spicules, the latter not very unlike those at the apex of *Euplectella;* and this opening seems to be the point of attachment to small stones, etc. The whole sponge is densely hispid with projecting spicules, which are sometimes of considerable length. These are mostly very attenuate; some of them are simple, and these are either straight or flexuous; others are simply ternate or biternate at one end; some again are anchorate at the extremity, with three or four slender flukes. In its canal connecting the three external and larger openings, and in its beautiful open network of spicules, it seems to differ generically from *Tethea.* In the shape of its spicules, but not in some other respects, it resembles the *Dorvillia agariciformis* of Mr. W. S. Kent, and the *Tethea muricata* of Bowerbank. As the Canadian sponge may possibly be the same as Dr. Bowerbank's imperfectly characterized species, I refrain for the present from giving it a name. It is only fair to add that before I had dredged this species in a living state, my friend Mr. G. T. Kennedy, M.A., had found specimens in the Post-Pliocene clays of Montreal, which are undoubtedly conspecific with it.

ECHINODERMATA.—*Schizaster fragilis* Dub. & Koren, and *Ctenodiscus crispatus*, are common in the deep-sea mud, as are also *Ophiacantha spinulosa* M. & T., and an *Amphiura* whose specific relations are still obscure. The Ophiuridæ collected during this cruise have yet to be studied. One living example of **Ophioscolex glacialis* M. and T. was dredged in 210 fathoms, to the southwest by south of the Southwest Point of Anticosti.

NOTE.—I am indebted to Prof. Verrill for the identification of several critical species, to whose names an asterisk (*) is prefixed; and the difficult Crustacea, whose appellations are preceded by a dagger (†), were kindly determined for me by Mr. S. I. Smith.

ACTINOZOA.—A few individuals of *Pennatula aculeata* Dan., var., and of *Virgularia Ljungmanii* Köll., were taken in the deep-sea mud, together with large tubes apparently belonging to *Cerianthus borealis* Verrill, though the animal of this latter species has not yet been taken in the Gulf. *Cornulariella modesta* Verrill was collected (in 1871) at depths of 220 fathoms, between the east end of Anticosti and the Bird Rocks.

POLYZOA.—A beautifully perfect specimen of *Flustra abyssicola* of G. O. Sars, showing the singular avicularia, so characteristic of the species, was dredged in the center of the mouth of the river, at a depth of 220 fathoms. Two examples of *Hornera lichenoides* (Linn.) and one of a peculiar variety of *Bugula plumosa ?* were dredged in the same place. *Escharella palmata* (M. Sars) was also sparingly taken in deep water.

MOLLUSCA.—The most abundant species collected at greater depths than 150 fathoms are *Pecten Grœnlandicus* Ch., and *Arca pectunculoides;* but *Portlandia lucida, P. frigida, Philine quadrata, Cylichna umbilicata* Mont., *Dentalium attenuatum* * ? Say, and *Siphonodentalium vitreum* Sars also occurred, though more sparingly. Two living specimens of *Cerithiopsis costulata* Möll. (the *Bittium arcticum* of Mörch) were dredged in the 220 fathom locality.

CRUSTACEA.—The deep-sea Crustacea are of unusual interest. Among them is a living specimen of *Calocaris MacAndreæ* Bell, the first, I believe, that has been observed on the American side of the Atlantic. In the same region, four specimens of a crustacean were collected, which belong, in my judgment, to a new genus.† In its characters, this genus (for which I venture

* If the shell described by the late Dr. Gould as *Dentalium dentale* be really the *Dentalium attenuatum* of Say, the latter name is much prior to Stimpson's *D. occidentale.* Having received a number of Norwegian specimens of *D. abyssorum* Sars, through the kindness of Mr. Jeffreys, and compared them with the St. Lawrence longitudinally ribbed species, I cannot see any differences which in my judgment are sufficient to separate them. At the same time, *Dentalium striolatum* St. seems to me a perfectly distinct and good species.

† *Munidopsis curvirostra*, nov. gen. et sp. External antennæ about equal in length to the carapace and its rostrum; internal ones very short, not reaching farther than about one-fourth the length of the beak. Eyes *rudimentary*, longitudinally oval, light yellowish in color; *cornea devoid of facets.* Carapace squarish, but longer than broad, with an outwardly directed straight spine on each of the front angles. Upper surface of the carapace granulate, hispid, transversely irregularly plicate. In the center there are two dorsal spines, placed one above the other, but at some distance apart. These, as are two similar spines on the tail segments, are all

to propose the name *Munidopsis*) approaches nearer to *Munida* than to *Galathea*. On some future occasion I hope to be able to give a detailed description, with figures, of this form; for the present a short diagnosis only of some of its salient points will be attempted. Of the limited genus *Munida*, only two or three species are known at present. *Munida rugosa* (Fab.) is the same as *Munida Rondeletii* of Bell, and *Astacus Bamffius* of Pennant. The other species are *M. tenuimana* of G. O. Sars, and *M. Darwinii* of Bell.

The following additional species of Crustacea were collected from the deep-sea mud: †*Hippolyte Fabricii* Kroyer; †*Diastylis*, sp.; †*Pseudomma roseum* G. O. Sars; †*Thysanopoda neglecta?* Kroyer, and another large species; *Stegocephalus ampulla* Phipps; †*Harpina*, sp.; †*Epimeria cornigera* Fab.; †*Halirages fulvocinctus* Bœck; †*Melphidippa*, sp.; *Phoxus Kroyeri* St.; *Munnopsis typica* M. Sars; *Anthura brachiata* St.; and †*Nebalia bipes* O. Fab.

FISHES.—A fine living example of *Macrurus rupestris* (Fab.), the *M. Fabricii* of Sundevall, was brought up by "tangles" from a depth of about 200 fathoms.

During this cruise we were driven into Gaspé Bay for shelter from a heavy gale, blowing outside, and were detained there about four days. At the entrance of the bay, some dredging was done in depths of from 30 to 50 fathoms. The most interesting species obtained here were *Myriotrochus Rinckii* Steenstr.; *Priapulus caudatus;* both species of *Hyas;* a species of †*Eudorella;* *Acanthozone*, nov. sp., fide S. I. Smith; †*Syrrhoë crenulatus* Goes (several); †*Vertumnus serratus* Goes; †*Pontoporeia femorata* Kroyer; †*Haploops*, sp.; †*Melita dentata* Kroyer, and an allied species; as well as some interesting sponges. †*Gammarus ornatus* Edwards was abundant at low-water in St. George's Cove; it appears to be an abundant littoral form throughout the gulf.

Cruise 2.—We left Gaspé Basin on August 2d, intending first to examine the two largest of the inshore banks, the Orphan and the Bradelle. At the outset the weather was very stormy, so we got under the lee of Bonaventure Island, and dredged out-

exactly in a line with the rostrum, and the whole four point forward. Rostrum *simple* (without the spine on each side of the base so characteristic of *Munida*), *conspicuously curved upward*, stout at the base and gradually tapering to a fine point. A single spine in the center of the first and second tail segments, the rest devoid of any. Anterior pair of legs about as long, but not longer, than from the apex of the rostrum to the end of the tail, extending a little beyond the tips of the outer antennæ. The following are the measurements of an average and apparently adult female: length, from apex of rostrum to tip of tail, 1·38 inch; of carapace, including the rostrum, ·69 inch; of exterior antennæ, ·75 inch; of anterior legs, ·94. Inhabits the center of the mouth of the St. Lawrence River, between Anticosti and the south shore, in from 180 to 220 fathoms, and probably burrows in the deep-sea mud. From *Munida* it may at once be distinguished by its curved and simple rostrum. In the rudimentary character of its eyes it closely resembles *Calocaris*, but not in many other respects.

side the northern entrance to the Bay des Chaleurs, from Cape Despair to a little below Grand Pabou. *Ophioglypha Sarsii*, of large size, was abundant here, and two specimens of *Myriotrochus Rinckii* were taken in the same place. The crustaceans from this region are unusually interesting: among them are †*Hippolyte macilenta* Kr.; *Thysanopoda neglecta?* Kr.; †*Pseudomma* (nov. sp.); species of †*Mysidæ* "near to *Erythrops* and *Parerythrops* of G. O. Sars"; †*Eudorella*, sp.; †*Leucon nasicus* Kroyer; †*Acanthostephia Malmgreni* Bœck; *Œdiceros lynceus* M. Sars; †*Aceros phyllonyx* Bœck; †*Byblis Gaimardii* Kroyer; †*Pontoporeia femorata* Kroyer; a species of †*Melita*. Also a curious fish, at present undetermined.

The breeze moderating, we at once made for the Orphan Bank, and devoted three days to dredging on it, remaining on the ground during the night so as to lose no time. The Orphan Bank, which is situated nearly opposite the entrance to the Bay des Chaleurs, is a stony patch, as are most of the fishing banks, many of which are not mapped out in the charts.

The masses of rock are often of large size, and consist chiefly of a reddish sandstone (perforated by *Saxicava* and *Zirphæa crispata*) associated with a few scattered pieces of Laurentian gneiss, &c. Soft-bodied organisms are peculiarly plentiful on this bank. The most characteristic of these are *Alcyonium rubiforme* Ehr., small varieties of *Metridium marginatum; Ascidiopsis complanatus*, of unusual size and abundance; various other Tunicates; and quantities of common Ophiurids and Asterids. †*Metopa glacialis* Bœck was occasionally met with between the inner and outer tunic of *Ascidiopsis*. The stones are often covered with encrusting sponges, of two or three species, together with a slender, cylindrical, and rarely branched, form; *Grantia ciliata* was frequent, and with it there occurred another calcareous sponge which Prof. Verrill has identified as the *Ascortis fragilis* of Hæckel. Hydrozoa and Polyzoa are exceedingly abundant on this bank; the former seem to be mostly common northern forms. Among the latter, *Myriozoum subgracile* D'Orb.; *Celleporaria incrassata* Lam.; *Cellepora scabra* Fab.; *Eschara cervicornis?* Pallas; *Caberea Ellisii;* and other species, were fine and frequent. Two fine specimens of *Porella lævis* (Fleming) were dredged at this locality. **Boltenia ciliata* Möller; **Molgula pannosa* V.; *Cynthia pyriformis* (Rathke); and *C. monoceros* Möll., occurred sparingly among the other Tunicates.

Among the Echinoderms are *Pteraster militaris*, *Asterias Grœnlandicus*, and *Psolus phantapus*. The rarest of the Orphan Bank Mollusca are *Amicula Emersonii* (Couth.), fine and frequent; *Mamma immaculata* (Totten); *Trophon craticulatus* (O. Fab.); *Buccinum tenue* Gray; *Neptunea Spitzbergensis* (Reeve); *Tritonofusus Kroyeri* Möll.; *Astyris Holbollii* Beck; and a few

Astarte lactea of Brod. and Sowerby. Crustacea are peculiarly plentiful on this bank, particularly the two species of *Hyas*; *Eupagurus*; *Pandalus annulicornis*; *Crangon boreas*; *Nectocrangon lar* (fine): *Hippolyte spina*; †*H. Phippsii*; and †*H. pusiola*. The Amphipods are represented by *Acanthozone cuspidata* (Lep.); *Tritropis aculeatus* (Lep.); and *Eusirus cuspidatus*. The Isopods by *Idotea marmorata* Packard, and by a *Bopyrus* which was found burrowing under the carapace of the common *Pandalus*. A small species of *Nymphon* was also dredged here.

At the end of the third day a stiff breeze from the southwest sprung up, accompanied with rain, and in consequence of this we made for Miscou Island for shelter. As soon as the gale moderated we proceeded to the Bradelle Bank, and on our way made one cast of the dredge between it and Miscou. In this haul, specimens of †*Hippolyte macilenta*; †*Pseudomma*, nov. sp.; †*Byblis Gaimardii*; †*Ampelisca*, sp.; †*Ptilocheirus pinguis* St.; †*Melita dentata*; and †*Pontoporeia femorata*, as well as many Annelids, were collected.

The Bradelle Bank, which is situated almost due south of the one previously described, is also a stony patch, but the pieces of rock are usually small, and there is an admixture of gravel, coarse sand and mud. Its fauna is characterized by the abundance of its Mollusca, and by the apparent absence on it of many of the softer organisms so abundant on the Orphan Bank. The Hydrozoa and Polyzoa of the two banks are very similar, but on the Bradelle fine specimens of *Tubulipora lobulata* Hassall, were collected. The most abundant shells on the Bradelle are *Astarte lactea* Brod. and Sow., *A. elliptica*, and *A. Banksii*; *Venus fluctuosa* Gould; *Cardium Grœnlandicum*; *Crenella nigra*; *C. lævigata*; *C. glandula*; *Macoma calcarea*; *Panopæa Norvegica*; and *Cyrtodaria siliqua*. Its greatest rarities are a single living example each of *Tritonofusus latericeus* Möller, and *Volutopsis Norvegicus* Chemn. *Rhynchonella psittacea*, of large size, is common on both banks. *Astrophyton Agassizii*; *Ophioglypha Sarsii*, large; *O. nodosa*; and *Psolus phantapus* are frequent on the Bradelle, where also a fine living specimen of *Ophiocoma nigra* Müller was obtained. The Crustacea of both banks are for the most part similar, but on the Bradelle a few additional species occurred. These are *Crangon vulgaris*; †*Diastylis*, sp.; †*Ampelisca*, two species; †*Haploops*, sp.; †*Byblis Gaimardii*; †*Ptilocheirus pinguis*; †*Harpina*, sp.; †*Paramphithoë pulchella* Bruz.; †*Œdiceros lynceus*; †*Vertumnus serratus*; and †*Nebalia bipes*.

These two banks seem to be outliers, so to speak, inhabited by a purely arctic fauna, and surrounded almost entirely by a more southern assemblage. The shores of the Magdalen Group, of Prince Edward and Cape Breton Islands, as well as the whole of Northumberland Straits as far north as the southern entrance to the Bay des Chaleurs, are tenanted by a somewhat meager Acadian fauna. Owing to the shallowness of the water on these two banks, the temperature is probably higher by some four or five degrees than the average of that in the northern part of the gulf. In sailing from Point Miscou to the Bradelle Bank we found the temperature of the bottom (Miscou Point, bearing northwest half north, 22 miles distant) was 42° Fahr. After examining the Bradelle Banks, we made for Pictou, Nova Scotia, and arrived there on the afternoon of August 11th.

Cruise 3.—Leaving Pictou on the 13th of August, we dredged to the S.W. and S.S.W. of Pictou Island, then to the N.E. and N.N.E. of Cape George (N. S.), and from there to a little distance off Port Hood, C. B. We next stood over to the east point of Prince Edward Island, dredging at intervals on the way. After this we examined the Milne Bank, also various parts of the bottom from there to Cape Bear (Prince Edward I.), and to the north of Pictou Island, and got back to Pictou on the 16th of August.

From Pictou to Port Hood and along the west side of Cape Breton, the sea bottom consists of red clayey mud, in which annelids are remarkably numerous and often of large size. At almost every cast of the dredge, tangled masses of tubicolous annelids (inhabiting tubes of from the $\frac{1}{16}$th to a quarter of an inch or more in diameter, and from one or one and a half inches to nearly eight inches in length came up in handfulls. These, together with large naked species, are so abundant as to form more than two-thirds of the whole number of specimens taken. One specimen of †*Diastylis quadrispinosus* G. O. Sars, was dredged off Pictou Island. Hydrozoa and Polyzoa are tolerably abundant, and sometimes very fine, in the red mud; these have not yet been examined, but among them are *Sertularia argentea* of unusually large size, and a bushy species of *Gemellaria*. *Alcyonium carneum* Ag., is one of the characteristic species of the eastern part of this area, as is also an apparently undescribed species of *Priapulus*, very distinct from *P. caudatus*. Tunicates are not unfrequent in the red mud; the commonest of which are *Pelonaia arenifera* and *Eugyra pilularis*, while **Glandula fibrosa* St., occurred more rarely. With these, about sixteen species of shells were collected; they are all characteristic Acadian species. The temperature of the mud seems to range from 40° to 42° Fahr. Off Port Hood, two large specimens of a Holothurian were taken, which exactly agree with the drawing and description of the *Cucumaria pentactes* of O. F. Müller, as given by E. Forbes in his British Starfishes.

Off the east point of Prince Edward Island the bottom is sandy, and as the depth where we dredged does not exceed fifteen or twenty fathoms, the summer temperature is high, being affected by surface conditions. Three small specimens of *Echinocucumis typica* M. Sars were collected here, as well as examples of **Molgula papillosa* V. and *M. producta* St. On the Milne Bank we dredged quantities of the common *Echinarachnius;* an abundance of fine Hydroids and Polyzoa; a few shells; and some small algæ.

Between Cape Bear and Pictou Island the bottom is sandy, with shells and a few small stones. Three kinds of sponges were collected here, many hydroids, echinoderms (all common forms), annelids, crustacea, and tunicates. Among the latter are specimens of **Molgula littoralis* V. Shells were particularly abundant, among them are *Pecten tenuicostatus*, *Modiola modiolus*, *Crenella nigra*, *Astarte undata* Gould, *Cyprina Islandica*, *Callista convexa*, *Pandora trilineata?*, *Crepidula fornicata*, *Lunatia triseriata*, *Mamma immaculata*, and several species of *Bela*.

The fauna of the region north of Pictou, between the west coast of Cape Breton and the east of Prince Edward Island, is essentially of an Acadian type. To the north, northwest, and west of Cape Breton, the deep water assemblage has probably an Arctic character.

In the marine slip at Pictou, I collected specimens of *Teredo navalis* and *T. Norvegica*, burrowing into the black birch of which the roller frames of the cradle are composed. At Souris, (Prince Edward I.), the common periwinkle of England (*Littorina littorea*) was plentiful, and it was subsequently observed at Charlottetown. An *Argulus*, closely allied to *A. Alosæ* of Gould, if not identical with it, was taken off Pictou Island, in towing nets, attached to *Gasterosteus biaculeatus?* and other small fishes. *Idotea irrorata* Say, was common on the surface at the same place, and was subsequently obtained at Shediac Bay, and elsewhere. On the shores of the Magdalen Islands it is tolerably common.

Cruise 4.—In the last cruise we endeavored to explore both sides of Northumberland Straits, and dredged from Pictou as far to the northwest as Miramichi Bay. Leaving Pictou on the 19th of August, we first dredged a little to the N.N.W. of Pictou Island, and were then compelled by stormy weather to take shelter in Shediac Bay. Being detained at Point du Chene for two days, we availed ourselves of the opportunity to examine the oyster beds of Shediac Bay. On these beds, from low water mark down to three fathoms, the following species were met with:

CRUSTACEA.

Cancer irroratus *Say.*
Crangon vulgaris *Fab.*
†Gammarus ornatus *Edw.*
Idotea irrorata *Say.*

MOLLUSCA.

Ostrea borealis *Lam.*
O. Virginiana *Lister.*
Mytilus edulis *Linn.*
Modiola modiolus *Linn.*

Mercenaria violacea *Schum.*
Gemma Tottenii *St.*
Callista convexa *Say.*
Petricola pholadiformis *Lam.* and var. dactylus.
Mactra solidissima *Chemn.*
Mya arenaria.
" truncata.
Angulus tener *Say.*
Thracia Conradi (fine and frequent).
Pandora trilineata? *Say.*
Solen ensis. v. Americana.
Teredo, sp. (in a spruce log).
Haminæa solitaria *Say.*
Cylichna pertenuis *Migh.*
Lottia alveus *Conrad.*
Crepidula fornicata *Linn.*
" unguiformis *Lam.*
Paludinella minuta.
Odostomia trifida *Totten.*
Turbonilla interrupta *Totten.*
Lunatia heros *Say.*
Bittium nigrum *Totten.*
Nassa obsoleta *Say.*
" trivittata *Say.*
Astyris lunata *Say.*

ECHINODERMATA.

Asterias vulgaris *St.*
Cribella sanguinolenta.
Echinarachnius parma.
Echinus Dröbachiensis.
Caudina arenata (*Gould*).

Leaving Shediac by daybreak on the 22d of August, we dredged from that place to the Egmont Bank, and stood back again to the south shore the same evening. The Egmont Bank is a small rocky patch, situated between Shediac Bay and Cape Egmont, Prince Edward Island. The depth on it is less than ten fathoms, and the bottom consists of coarse sand and stones, the latter covered with *Laminariæ* and smaller algæ, and perforated by *Petricola pholadiformis.* Annelids are numerous in the sand, from which also about twelve species of shells were collected. Early the next morning (August 23d), we stood over to the Prince Edward Island side, and dredged along the outside of Bedeque Bay, from off St. Jacques to a little to the south of Sea Cow Head. In the afternoon a falling barometer indicating the imminent approach of a storm, we made for Charlottetown, and reached there only just in time to weather out the memorable gale of the 24th of August. We subsequently managed to dredge in Hillsborough Bay, also, on the opposite shore, off Pugwash Harbor, N. S., and off Shediac, Buctouche and Richibucto, in New Brunswick, and on the 9th of September I left the schooner and proceeded home. On the Prince Edward Island side of Northumberland Straits proper, the bottom is usually a red (Triassic) clayey mud, while on the New Brunswick side it is generally sandy. The fauna of the Straits is of a meager Acadian type. A few sponges, hydriods and crustaceans collected here have yet to be studied. The annelids are fine and frequent, but the echinoderms are all very common species. At depths of more than four fathoms, in Northumberland Straits, the following species were collected:

CRUSTACEA.

Homarus Americanus (fry.)
Crangon vulgaris.
†Hippolyte pusiola *Kr.*
†Diastylis lucifera.
† " sculpta? *G. O. Sars.*
†Pontoporeia femorata.
†Unciola irrorata *Say.*
†Amphithöe, *sp.*
†Ptilocheirus pinguis.
†Melphidippa, *sp.*
†Idotea phosphorea *Harger.*

TUNICATA.

*Eugyra pilularis *V.*
Pelonaia arenifera *St.*

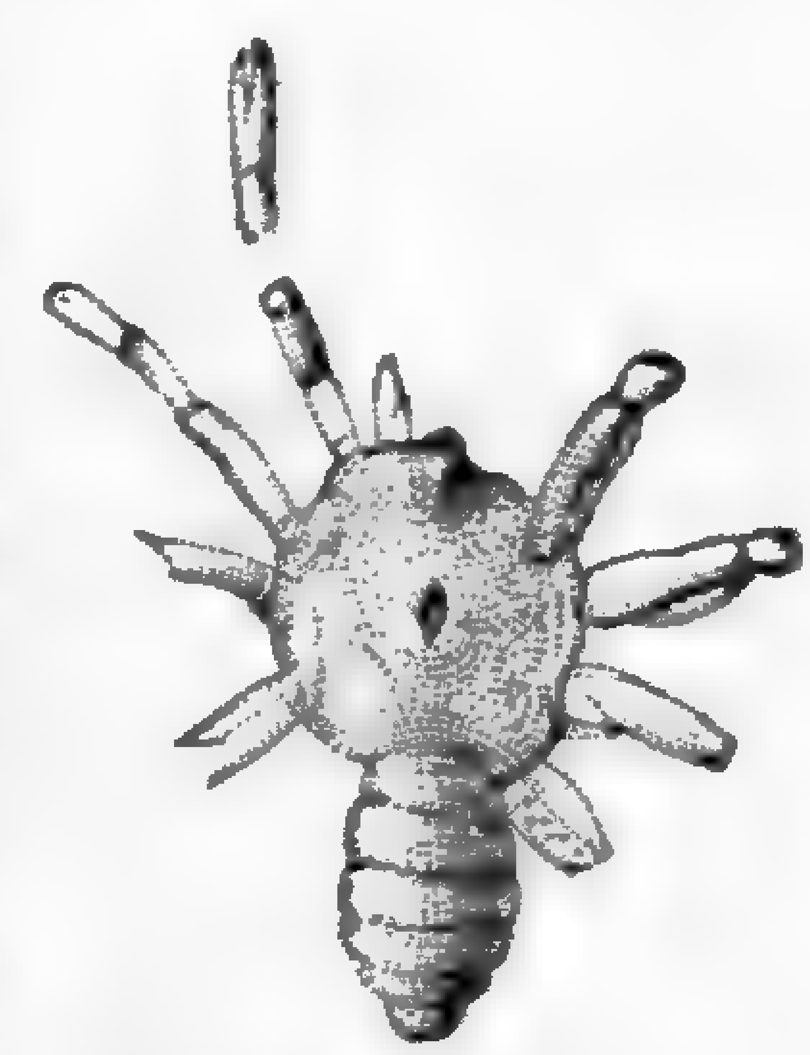
MOLLUSCA.	Petricola pholadiformis *Lam.*
Pecten tenuicostatus *Migh.*	Mactra lateralis *Say.*
Yoldia limatula *Say.*	Pandora trilineata ? *Say.*
" sapotilla *Gould.*	Turbonilla interrupta *Totten.*
Nucula delphinodonta *Migh.*	Lunatia triseriata *Say.*
Astarte undata *Gould.*	Nassa trivittata *Say.*
Cyprina Islandica *Linn.*	Buccinum undatum *Linn.*
Cardium pinnulatum *Con.*	Sipho pygmæus *Gld.*
Callista convexa *Say.*	Bela cancellata *Migh.*

ART. XXVI.—*Notice of a new Fossil Spider from the Coal Measures of Illinois;* by O. HARGER.

Arthrolycosa antiqua*, gen. et sp. nov.

THE fossil spider, represented in the accompanying figure, was found by Mr. S. S. Strong, in one of the well known iron-stone concretions from Mazon Creek, Grundy County, Illinois, in "the lower part of the true Coal Measures," and is now preserved in the Museum of Yale College. The specimen, as seen upon the fractured surface of the concretion, presents for examination only the dorsal surface, and the other half of the concretion, or the cover, adds little or nothing to the knowledge of the fossil.

The outline of the cephalothorax in the specimen is indistinct, but measures about 10^{mm} (·4 in.) in length by 9^{mm} (·35 in.) in breadth. Near its anterior margin is a tubercle, which seems to present traces of a median longitudinal division, as if a pair of oval eyes had occupied its lateral portions. Behind this tubercle and near the middle of the cephalothorax is a pit or impression in the surface, and a little posterior to this a transverse ridge, somewhat convex forward. Other depressions and irregularities upon the surface seem to be unsymmetrical, and are probably accidental, or perhaps evidence that it has been flattened from an originally convex form. In front of the cephalothorax are two short, stout, divergent organs, apparently the mandibles, only one of which is shown in the figure. Upon the upper interior surface of the left mandible are two shallow longitudinal grooves, separated by a narrow rounded ridge. On the left side of the cephalothorax, and behind the mandible, are four appendages, probably the palpus and the first three legs, the fourth leg on the left side being absent. The first of these four appendages shows, in connection with the cephalothorax, two segments and a part



* From ἄρθρον, *a joint*, and λύκος, *a spider*, referring to the segmentation of the abdomen.

of a third. The first two of these segments are about equal in length, but the third is broken near its proximal articulation, and the connection of this appendage with what seems to be its distal cheliform segment is unfortunately imperfect. This segment is also poorly preserved, and the articulation of its digit is only to be seen with a good magnifier and in a certain light. The length of this segment is 5·5^{mm} (·22 in.); greatest breadth, 1·5^{mm} (·06 in.); length of digit, ·4^{mm} (·15 in.). I do not, however, consider the forcipulate character of this segment beyond a doubt. It is perhaps not improbable that it may have been modified much as in the males of ordinary spiders, and not truly forcipulate. The next appendage on the left side, which I have considered the anterior leg, presents a long, pretty well defined segment, doubtless the third or femoral segment, and traces of its proximal as well as its distal articulation, beyond which two other shorter segments are but poorly preserved, as shown in the figure. The next leg shows only the long or femoral segment, with indications of the trochanter, and the third leg on this side is even less well preserved. I suppose the fourth leg on this side to be entirely wanting.

On the right side of the specimen, immediately to the right of the mandible, the margin of the cephalothorax presents an elevation, and there is apparently nothing but the very base of the right palpus remaining. Two segments of the first leg are preserved, the first being much the longer: the second leg is preserved in a similar manner, and the third also. The first segment of the fourth leg on this side has been much flattened by pressure. On the surface of its posterior portion are a number of minute pits or depressions, the larger of which are represented in the cut. The same structure may be seen in a much less degree upon the third leg of the same side, and traces of it may be observed upon one or two of the other appendages. Another portion of the fourth leg of the right side is perhaps preserved in what appears to be a segment, or parts of two segments, a short distance to the right of and behind the end of the first segment, and not shown in the figure.

The abdomen consists of seven segments, the first being short and the last two short and somewhat indistinct. Its length equals that of the cephalothorax, 10^{mm} (·4 in.), its greatest breadth, 6·5^{mm} (·25 in.), breadth at union with cephalothorax, 4^{mm} (·15 in.). Two longitudinal grooves inclosing a long oval area near the middle of the anterior part of the abdomen, and of about half its length seem to have been caused by pressure, and the upper surface of the abdominal segments was probably in life smooth, as I see no evidence of the presence of hairs, tubercles, pits or grooves, nor of abdominal appendages of any kind, and the irregularities presented by the specimen appear to be owing to the accidents of its preservation. The presence or absence of spinnerets cannot be determined.

In considering the relations of this insect to previously known living and fossil forms, the more important points of structure to be regarded are, the segmentation of the abdomen and its union with the cephalothorax, the character of the palpi, the position and number of the eyes, and the cephalothoracic pit.

The segmented character of the abdomen seems to be beyond a doubt Mr. J. H. Emerton, in a letter to Prof. Marsh, has called attention to an aberrant spider described by Schiödte, under the name of *Lipistius desultor*,* in which the abdomen is destitute of spinnerets and furnished above with a series of nine horny plates. The abdomen of *Lipistius* would doubtless, under similar circumstances, bear a considerable resemblance to that of *Arthrolycosa*, and it is perhaps not impossible that the segmented appearance in the fossil may have been produced by a similar cause. The difference in the number of such plates would probably be a matter of comparatively slight structural importance. There seems, however, no good reason for explaining the apparent segmentation of the abdomen in the fossil by any other than the most natural and obvious cause, namely, that it was actually segmented in its structure. The small number of abdominal segments, apparently only seven at most, is an interesting point. If its segmented character is, as has been suggested by Mr. Scudder and others, to be considered a synthetic or embryonic feature, it would indicate in this early form the partial atrophy of the post abdomen as in the true spiders, where, as has been shown by Claparède for the genus *Pholcus*, there are only five embryonic abdominal rings.

Unfortunately, in his description of *Protolycosa anthracophila*,† Römer does not state distinctly whether the abdomen is segmented or not. His figures indistinctly indicate nine or ten segments in its abdomen, while in the discussion of its zoölogical affinities, he implies that the abdomen was not segmented and even more directly in the statement, "Von dem Vorkommen ächter Spinnen mit ungegliedertem Hinterleib (*Araneæ*) in älteren Schichten lagen * * * * * bisher nur ganz unsichere oder unvollständige Angaben vor." The specimen presents no traces of the peculiar abdominal appendages of *Protolycosa*, nor of the circular opening at the extremity of the abdomen, nor of transverse rows of tubercles. There seems to be no good evidence that the union of the cephalothorax and abdomen was as delicate as in ordinary

* Naturhistorisk Tidsskrift, II, vol. ii, p. 617, pl. v, 1849.

† Neues Jahrbuch für Mineral. Geol. u. Palæont. von Leonhard u. Geinitz, p. 136, pl. III. Stuttgart, 1866.

spiders; the two were, however, well separated, and doubtless by a more decided constriction than appears in the specimen, thus differing from the fossil genera *Architarbus** and *Eophrynus*† and resembling *Protolycosa.*

The palpi in this specimen must be considered as absent on both sides unless the first appendage exterior to the mandible on the left side be regarded as a palpus, as seems to be the fact. The segments of this appendage do not correspond with those of the legs, as shown by the description and figure, the first two visible segments being of about equal length instead of the first being much the longer, as in the legs. The claw or hand at the extremity of this appendage is, as I have said, poorly preserved, but if a forcipulate structure existed at all, it is as distinct as in the false scorpions. and much more pronounced than in *Protolycosa*, where "the last segment of the left palpus appears to be divided by an incision at its extreme end." The presence of well developed forcipulate palpi in *Arthrolycosa* would indicate affinity with the false scorpions, or perhaps, as Prof. Verrill suggests, with *Thelyphonus.* The fossil, however, presents no trace of the long caudal stylet present in that genus. If the appendage in question be a palpus its size alone would point toward affinity with the lower arachnids (*Solpugidae*, *Phrynus*); if it be a leg, then the palpi were doubtless small as in most spiders, since little room is left for their articulation.

The tubercle upon which the eyes were probably situated seems a character indicative of affinity with the lower arachnids, where, as especially among the *Phalangidæ* and scorpions such a structure is common, although it may occur among true spiders, as in *Lipistius.* It is impossible to determine whether eyes existed upon other parts of the cephalothorax or not, and there is no reason for supposing their absence except such as may be drawn from the presence of an oculiferous tubercle. Unfortunately the eyes of *Protolycosa* have not been made out, but the cephalothorax of that fossil seems to have been destitute of a tubercle. This, together with the difference in the abdomen already mentioned, must be regarded as furnishing diagnostic characters of at least generic importance, to which may be added the cephalothoracic pit in *Arthrolycosa.* The mandibles resemble those of *Protolycosa*, and probably did not differ greatly from those of the true spiders.

I would not, however, refer *Arthrolycosa* to the true spiders, but consider it as representing a group of insects combining features now characteristic of separate groups and of embryonic states. The family which may be called the *Arthrolycosidæ* seems to have borne relations to the *Phalangidæ* and scorpions in its oculiferous tubercle, and to the latter group as well

* S. H. Scudder, Geol. Surv. Illinois, vol. iii, p. 568, fig. 4, 1868.
† H. Woodward, Geol. Mag., vol. viii, p. 385, pl. xi. London, Sept. 1871.

as the false scorpions and *Thelyphonus* in its forcipulate palpi. The union of the cephalothorax and abdomen appears to have been much as in *Thelyphonus*, although perhaps resembling that seen in the spiders, and as Mr. Scudder has suggested, separates the group from that to which *Architarbus* belongs, while it is allied to the lower arachnids in general and to the embryonic forms of the true spiders in its segmented abdomen. The general form of the insect is also much like that of the true spiders, among which the *Mygalidæ* have been mentioned by Mr. Emerton as near allies. The oculiferous tubercle and the cephalothoracic pit appear to sustain this opinion and if the examination of additional material should show that the palpi are not forcipulate, but are small and absent from this specimen, we should have in the *Arthrolycosidæ*, an interesting example of what might properly be called an embryonic type.

The thanks of the author are due to Prof. O. C. Marsh, and through him to Mr. S. H. Scudder and Mr. J. H. Emerton, for the kindly interest that these gentlemen have manifested, and for their valuable suggestions upon the literature of the subject and the affinities of the insect.

Yale College, New Haven, Feb. 9th, 1874.

ART. XXVII.—*On some Crystals of Zinc;* by S. P. SHARPLES, S.B.

(Read before the American Academy, Jan. 13, 1874.)

SOME years ago M. G. Farmer, of Boston, constructed a number of thermo-electric batteries, using an alloy of zinc and antimony for one of the elements, and German silver for the other.

The alloy of zinc and antimony contained about fifty per cent of each metal, an analysis giving 50·7 per cent of zinc. One of these batteries was kept constantly heated for upward of a year, and upon breaking it up the end of the zinc-antimony elements furthest from the point to which the heat was applied, were found to be covered with a moss-like growth of metal.

This moss was found under the microscope to consist of flat ribbon-like crystals, which were deeply striated in the direction of their length. Analysis gave ninety-eight per cent of metallic zinc. They are very tough and will bear a considerable amount of bending, while the alloy itself is as brittle as glass.

Prof. Cooke, in some experiments with zinc and arsenic, made some years ago, obtained similar crystals by subliming zinc in a closed tube, and I have observed these crystals in the prolonges of the zinc works in South Bethlehem, Penn. But in both these instances the zinc has been deposited from the vapor of metallic zinc, while in the other case the heat has not been great enough to even melt the asphaltum varnish with which the end of the element is covered. Cases of molecular re-arrangement are frequent, when this change takes place in the interior of a solid mass, but I have never before met with a case in which one metal was separated from another by such change and projected beyond the surface of the alloy.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the hydrocarbon Fluorene.*—This hydrocarbon was discovered by Berthelot in 1867, in that portion of coal-tar volatile between 300° and 340°. Barbier has recently submitted it to a more extended investigation. He prepared it by Berthelot's method, except that, instead of crystallizing the fraction distilling between 300° and 305° from alcohol alone, a mixture of alcohol and benzine was used, by which a small quantity of acenaphtene is separated. When pure, fluorene has a well pronounced violet fluorescence, which disappears on solarization. It fuses at 113°. The formula $C_{13}H_{10}$ was established for it: (1) by an elementary analysis; (2) by an analysis of the picrate, in which not only were the picric acid and the hydrocarbon determined, but also the carbon and the hydrogen; and (3) by a complete analysis of a well-defined bromide. The picrate crystallizes in fine red needles, fusing at 80°–82°, and has the formula $C_{13}H_{10}, C_6H_3(NO_2)_3O$. The bromide crystallizes in magnificent clinorhombic tables, fusible at 166°–167°, and has the formula $C_{13}H_8Br_2$. When heated to redness in presence of lime, the bromide yields a lamellar mass fusible at 100°, and being apparently diphenyl. If so, fluorene has the constitution of diphenylmethylene, $C(C_6H_5)_2$. When treated with an acetic acid solution of chromic acid, it yields an oxidation-product crystallizing in fine yellow needles, the character of which the author is now studying.—*C. R.*, lxxvii, 44[illegible], Aug., 1873. G. F. B.

2. *On Nitroanthracene and its Derivatives.*—More than a year ago, Schmidt announced that mono-nitranthracene yielded, on reduction with tin and hydrochloric acid, not anthracene itself but an isomer of it. He has now still farther examined this substance. Its fusing point (247°), so near that of para-anthracene (244), suggests its identity with this body. But that this cannot be appears from several facts. First, while para-anthracene by heat passes readily into anthracene, its fusing point falling to 213°, the new isomer may be repeatedly fused and even heated to 300° without any change in its fusing point. Moreover, its picrate, which is formed less easily than the similar anthracene compound,

crystallizes in beautiful red needles often an inch long. Upon analysis, however, they give the formula $C_{14}H_{10}, C_6H_2(NO_2)_3OH$. Nitric acid, boiling, converts the new hydrocarbon into a yellow nitro-product, $C_{14}H_9(NO_2)$, without a trace of a quinone. This nitro-product sublimes in beautiful pale yellow needles, which fuse at 209°. These reactions distinguish the new body sufficiently from anthracene on the one hand and para-anthracene on the other. Bromine yields with it a condensation product $C_{28}H_{19}Br_3$, fusing at 273°, subliming without decomposition and being unattackable by potassium hydrate. Very careful oxidation by means of chromic acid yields a quinone which has the formula $C_{14}H_8O_2$, which sublimes and crystallizes in magnificent red needles, fusing at 235°. Concentrated sulphuric acid dissolves this quinone with a splendid indigo-blue color; a very delicate test for it. Water separates the unaltered quinone from the solution. Sulphurous acid converts it into a colorless hydroquinone, which oxidizes readily in the air. Distilled with soda-lime, a hydrocarbon is produced which has not been yet studied.—*Ber. Berl. Chem. Ges.*, vi, 494, 1873. G. F. B.

3. *A new Synthesis of Glycocoll.*—EMMERLING has succeeded in effecting a new synthesis of glycocoll which is not only remarkable as a synthetic result of great importance, but also as illustrating certain fundamental points in chemical theory. Starting from the fact that hydrogen iodide is capable of exerting upon organic bodies a double action; that it can not only reduce them to the saturated hydrocarbon from which they are derived, but can also cause them by assimilating water to split up into two or more molecules, Emmerling advanced to his synthesis. The method was simple; cyanogen gas was passed through a concentrated solution of hydrogen iodide. One of the cyanogen atoms in the molecule, by hydrogenation, became the methylamine residue CH_2NH_2; the other, by exchanging its nitrogen for the elements of water, gave rise to a carboxyl group, COOH. The formation of glycocoll therefore takes place according to the following equation:—

$$\begin{matrix} CN \\ | \\ CN \end{matrix} + (HI)_5 + (H_2O)_2 = \begin{matrix} CH_2NH_2 \\ | \\ COOH \end{matrix} + NH_4I + I_4.$$

The yield is considerable and the properties of the glycocoll are identical with those of that of organic origin. The author thinks this result goes far to prove that the reason why uric acid yields glycocoll by treatment with HI, is because it contains a cyanogen molecule; in opposition to the view of Strecker, that the glycocoll existed partially preformed in the uric acid.—*Ber. Berl. Chem. Ges.*, vi, 1351, Dec., 1873. G. F. B.

4. *On an Isomer of Alizarin, Quinizarin.*—GRIMM has recently confirmed the statement of Baeyer, that, like the other phenols, hydroquinone combines directly with phthalic acid. He finds, however, that, when the two are warmed to 130°–140° with concentrated sulphuric acid, two bodies are formed; one the phthalein of hydroquinone, which is colorless and resembles

closely the phthalein of phenol; the other a red coloring matter, an isomer of alizarin—to which Grimm gives the name quinizarin—which unfortunately is produced in very small quantity, only 1–2 per cent of the theoretical yield. It is prepared by treating the mass as above obtained with absolute alcohol and then precipitating with water; or by solution in benzole, which dissolves the quinizarin, leaving the phthalein. Recrystallization from alcohol and ether afford it pure, and it then has the composition $C_{14}H_8O_4$. It is produced according to the equation:

$$C_8H_4O_3+C_6H_6O_2=C_{14}H_8O_4+H_2O.$$

From ether it crystallizes in yellow plates, from benzole and alcohol in deep red needles. Water throws down yellowish red flocks, which become crystalline on heating. The etherial and sulphuric acid solutions show a greenish-yellow fluorescence. The former shows a brownish yellow color by transmitted light, the latter a peculiar violet, passing by dilution into a bright onion-red. This suggests its possible relations with munjustin. Alkalies dissolve quinizarin to a deep blue color. Since anthracene results when its vapor is passed over heated zinc dust, Grimm suggests its close similarity with alizarin, and proposes for it the rational formula

$$C_6H_4\genfrac{}{}{0pt}{}{-\cdot-CO-\cdot-}{-\cdot-CO-\cdot-}C_6H_2(OH)_2.$$

—*Ber. Berl. Chem. Ges.*, vi, 506, 1873. G. F. B.

5. *The Horizontal Pendulum.*—Zöllner describes a series of experiments with a form of horizontal pendulum of such surprising delicacy that it seems to open a wide and fruitful field for investigation. This instrument consists of a short horizontal rod suspended by a vertical piece of fine watch-spring, and carrying at one end a heavy leaden weight and mirror. To prevent the other end from rising, a second watch-spring is attached, and fastened below. The two points of support lie therefore nearly in the same vertical, and are equidistant, one above and the other below, the pendulum. They are connected with the top and bottom of a vertical rod, which rests on a tripod, with leveling screws. If the two points lie in the same vertical, the weight will remain in any position; but if one of the leveling screws is slightly moved, the pendulum will assume a position of equilibrium around which it will vibrate, if disturbed. It will act, in fact, precisely like a common pendulum, except that the effect of gravity has been greatly diminished, so that the time of vibration is increased. Its sensibility is of course readily varied by shifting the levelling screw. In the instrument actually employed, the pendulum weighed about six pounds, and when removed from its supports and vibrated vertically like a common pendulum, its time of oscillation was about ·25 of a second. The springs were about eight inches long and the delicacy of the instrument was such that its vibrations were easily observed when the time was increased to thirty seconds, corresponding to a diminution of the force of gravity of fourteen thousand times. In the actual experiments a time of vibration of

14·44 seconds was employed. The motions were observed by viewing the reflections of a scale at a distance of 3168^{mm} from the mirror. The whole instrument was mounted on a stone pier and protected with great care from air currents, or changes of temperature. The instrument was so susceptible to disturbing influences, that it was set in motion by a railway train passing at a distance of about a mile.

Any change in the direction of the force of gravity would produce a corresponding motion of the pendulum, and in the present case a change of ·001 of a second of arc would be perceptible, or would alter the scale-reading ·1 of a millimeter. New the calculations of Dr. C. A. F. Peters show that the effect of the moon when at its maximum produces a deviation of ·0174″, or doubling this amount for the difference on the two sides of the meridian ·035″, or thirty-five times the amount perceptible with this instrument. The sun in like manner would produce a variation of ·016″. Hence it seems possible by this means to weigh directly the masses of the sun and moon in terms of the earth, and hence determine their distances. The deviation would change its sign whenever these bodies crossed the meridian, and hence if it could be accurately determined, would afford a means of measuring the time required by gravity to pass from the sun to the earth. Of course, such observations would be greatly disturbed by variations of temperature, shaking of the ground, and many other causes; and hence should be conducted in caves at a considerable distance from human habitation.—*Pogg. Annal.*, cl, 134. E. C. P.

6. *Specific heat of Gases under constant volume and under constant pressure.*—M. Amagat has measured that most important constant, the ratio of the two specific heats of gases, as follows. The simplest method would be that of MM. Clément and Desormes, were it not for the oscillation of the gaseous mass at the orifice, discovered and studied by M. Cazin. This complication is avoided by the method here employed, which consists in compressing a limited volume of the gas, at the pressure of the atmosphere, and determining its pressure immediately after its reduction in volume. The initial and final volume being determined without difficulty, it only remains to apply the formula of Poisson, $pv^{\frac{C}{c}}=p'v'^{\frac{C}{c}}$, in which the exponent $\frac{C}{c}$ is the unknown quantity.

It appeared at first difficult to determine almost instantly with a manometer the pressure of a gas which began immediately to cool. It was easily done, however, by the following method.

The gaseous mass, immediately after compression, was, by opening a stopcock, put in communication with a manometer of oil, previously set at a pressure a little less than that sought; so that the ascent of the manometric liquid was very slight. Closing the stopcock the manometer remained more nearly at the right height than before. Repeating this operation several times, the manometer at length remained stationary at the instant when the stopcock was opened, and marked then the desired pressure. This pressure was now determined by connecting a mercury manometer with the oil.

The compression of the gas was effected by a column of mercury rising rapidly in a large tube, which formed the prolongation of the neck of the flask in which the gas was enclosed. The pressure was communicated to the mercury by a layer of oil driven by a piston fitting into a copper cylinder. The heat which would be developed by friction if the piston compressed the gas directly was thus avoided; the compression was easily effected in half a second and the results were very concordant. The amount of the compression never exceeded three centimeters, and in the last series of observations, the greatest deviation from the mean was only a tenth of a millimeter.

By studying the descending motion of the manometer after the compression it was found that a slight correction could be applied for the lowering of the temperature of the gas during compression. Without the correction, for atmospheric air $\frac{C}{c}=1{\cdot}391$, and applying the correction $\frac{C}{c}=1{\cdot}397$.

It is evident, further, that we can avoid, or at least greatly diminish, the effect of cooling, by employing a large reservoir; the flask here used having a volume of scarcely twenty liters.

From the preceding result we deduce for the mechanical equivalent of heat the number 434, which differs only by a single unit from that recently found by M. Violle with Foucault's apparatus. An experiment with carbonic acid gave the results $\frac{C}{c}=1{\cdot}299$; an accident happening to the apparatus interrupting the study of this gas. There is reason to believe that this result is a little too great; moreover the gas was not entirely free from air.—*Comptes Rendus*, lxxvii, 1325. E. C. P.

7. *Relative intensity of the constituent rays of various sources of light.*—M. Trannin describes a form of photometer for comparing the intensity of the various simple colors of which every light is composed. It consists:—

(1.) Of two small right-angled prisms, placed one above the other and turned in opposite directions, so as to receive the rays from two sources of light placed opposite each other.

(2.) These prisms are placed in front of a narrow slit whose height is thus divided into two halves unequally illuminated. The light then enters a collimater by which it is rendered parallel, next a polarizer whose principal section is vertical, and then a plate of quartz about a centimeter thick, cut parallel to the axis and whose principal section makes an angle of 45° with that of the polarizer; finally, through an analyzer, having its principal section vertical, formed of a double image prism.

(3.) The dispersive prism and telescope of a spectroscope finally receive the luminous rays.

The double image prism doubling both rays makes the ordinary ray from one source coincide with the extraordinary ray from the other. But in general each of the elementary rays emerging from the plate of quartz is polarized elliptically, and we know that this kind of light after having traversed any doubly-refracting analyzer gives two images of unequal intensity polarized at right-angles, but whose sum is constant and equal to the sum of the squares of the velocities parallel to the two axes of the ellipse. The beam, after traversing the double-image prism, will then give a spectrum formed of three horizontal bands, in the field of the telescope. That in the center is due to the superposition of the extraordinary ray from one part of the slit, on the ordinary ray from the other part, and is consequently continuous, or as if it was completely unpolarized, if the two parts are equally illuminated. Above and below will be spectra traversed with bands, the dark spaces of one corresponding to the light ones of the other.

To make the observation, therefore, one of the lights must be diminished until the bands completely disappear from the central spectrum. This is accomplished by either withdrawing one of the sources of light, or by interposing a Nicol's prism between the eye and eye-piece, which may be turned through any desired angle. —*Comptes Rendus*, lxxviii, 1497. E. C. P.

8. *The Selection and Nomenclature of Dynamical and Electrical Units.**—We consider that the most urgent portion of the task entrusted to us is that which concerns the selection and nomenclature of units of force and energy; and under this head we are prepared to offer a definite recommendation.

A more extensive and difficult part of our duty is the selection and nomenclature of electrical and magnetic units. Under this head we are prepared with a definite recommendation as regards selection, but with only an interim recommendation as regards nomenclature.

Up to the present time it has been necessary for every person who wishes to specify a magnitude in what is called "absolute" measure, to mention the three fundamental units of mass, length, and time, which he has chosen as the basis of his system. This necessity will be obviated, if one definite selection of three fundamental units be made once for all, and accepted by the general consent of scientific men. We are strongly of opinion that such a selection ought at once to be made, and to be so made that there will be no subsequent necessity for amending it.

We think that, in the selection of each kind of derived unit, all arbitrary multiplications and divisions by powers of ten, or other factors, must be rigorously avoided, and the whole system of fundamental units of force, work, electrostatic, and electromagnetic elements, must be fixed at one common level—that level, namely, which is determined by direct derivation from the three fundamental units once for all selected.

The carrying out of this resolution involves the adoption of

* First Report of the British Association Committee on Units.

some units which are excessively large or excessively small in comparison with the magnitudes which occur in practice; but a remedy for this inconvenience is provided by a method of denoting decimal multiples and sub-multiples, which has already been extensively adopted, and which we desire to recommend for general use.

On the initial question of the particular units of mass, length, and time, to be recommended as the basis of the whole system, a protracted discussion has been carried on, the principal point discussed being the claims of the gram, the *meter* and the second, as against the gram, the *centimeter*, and the second; the former combination having an advantage as regards the simplicity of the name *meter*, while the latter combination has the advantage of making the unit of mass practically identical with the mass of unit volume of water; in other words, of making the value of the density of water practically equal to unity. We are now all but unanimous in regarding this latter element of simplicity as the more important of the two; and in support of this view we desire to quote the authority of Sir W. Thomson, who has for a long time insisted very strongly upon the necessity of employing units which conform to this condition.

We accordingly recommend the general adoption of the centimeter, the gram, and the second, as the three fundamental units: and until such time as special names shall be appropriated to the units of electrical and magnetic magnitude hence derived, we recommend that they be distinguished from "absolute" units otherwise derived, by the letters "C. G. S." prefixed, these being the initial letters of the names of the three fundamental units.

Special names, if short and suitable, would in the opinion of most of us, be better than the provisional designations "C. G. S. unit of . . . . ." Several lists of names have already been suggested; and attentive consideration will be given to any further suggestions which we may receive from persons interested in electrical nomenclature.

The "ohm," as represented by the original standard coil, is approximately 10^9 C. G. S. units of resistance. The "volt" is approximately 10^8 C. G. S. units of electromotive force, and the "farad" is approximately $\frac{1}{10^9}$ of the C. G. S. unit of capacity.

For the expression of high decimal multiples and sub-multiples, we recommend the system introduced by Mr. G. J. Stoney—a system which has already been extensively employed for electrical purposes. It consists in denoting the exponent of the power of 10 which serves as multiplier, by an appended cardinal number if the exponent be positive, and by a prefixed ordinal number if the exponent be negative. Thus:—

10^9 grams constitute a *gram-nine*,

$\frac{1}{10^9}$ of a gram constitutes a *ninth-gram.*

The earth's circumference is approximately four meter-sevens, or four centimeter-nines.

For multiplication or division by a million, the prefixes *mega** and *micro* may conveniently be employed, according to the present customs of the electricians. Thus the *megohm* is a million ohms, and the *microfarad* is the millionth part of a farad. The prefix *mega* is equivalent to the affix *six*. The prefix *micro* is equivalent to the prefix *sixth*. The prefixes *kilo*, *hecto*, *deka*, *deci*, *centi*, *milli* can also be employed in their usual senses before all new names of units.

As regards the name to be given to the C. G. S. unit of force, we recommend that it be a derivative of the Greek δύναμις. The form *dynamy* appears to be the most satisfactory to etymologists. *Dynam* is equally intelligible, but awkward in sound to English ears. The shorter form *dyne*, though not fashioned according to strict rules of etymology, will probably be generally preferred in this country. Bearing in mind that it is desirable to construct a system with a view to its becoming international, we think that the termination of the word should, for the present, be left an open question. But we earnestly request that, whichever form of the word be employed, its meaning be strictly limited to the unit of force of the C. G. S. system; that is to say, the force which, acting upon a gram of matter for a second, generates a velocity of a centimeter per second.

The C. G. S. unit of work is the work done by this force, working through a centimeter; and we propose to denote it by some derivative of the Greek ἔργον. The forms *ergon*, *ergal*, and *erg* have been suggested; but the second of these has been used in a different sense by Clausius. In this case also we propose for the present to leave the termination unsettled; and we request that the word *ergon* or *erg* be strictly limited to the C. G. S. unit of work, or what is, for purposes of measurement, equivalent to this, the C. G. S. unit of energy, energy being measured by the amount of work which it represents.

The C. G. S. unit of power is the power of doing work at the rate of one erg per second, and the power of an engine (under given conditions of working) can be specified in ergs per second.

For rough comparison with the vulgar (and variable) units based on terrestrial gravitation, the following statement will be useful:—

The weight of a gram at any part of the earth's surface is about 980 dynes, or rather less than a kilodyne.

The weight of a kilogram is rather less than a megadyne, being about 980,000 dynes.

Conversely, the dyne is about 1·02 times the weight of a milligram at any part of the earth's surface, and the megadyne is about 1·02 times the weight of a kilogram.

The kilogram-meter is rather less than the erg-eight, being about 98 million ergs.

The gram-centimeter is rather less than the kilerg, being about 980 ergs.

* Before a vowel, either *meg* or *megal* (as euphony may suggest), may be employed instead of *mega*.

For exact comparison the value of g (the acceleration of a body falling in vacuo) at the station considered, must of course be known. In the above comparisons, it is taken as 980 C. G. S. units of acceleration.

One horse-power is about three quarters of an erg-ten per second. More nearly, it is 7·46 erg-nines per second, and one *force de cheval* is 7·36 erg-nines per second.

The mechanical equivalent of one gram-degree (centigrade) of heat is 41·6 megalergs or 41,600,000 ergs.*

[The *dyne* or unit of force which is proposed by the committee is to be a new unit of the same nature as a gram-weight, or the earth's attraction for a gram-mass, and having no commensurable ratio with it. Now our simplest and most useful ideas of force are derived at once from weight. It seems to us that, of necessity, this will always be the case. Probably the learned committee have no expectation that even among scientific men the new units will entirely replace what they call the vulgar ones. If, then, their recommendation is accepted, we shall create for certain departments of mechanical science new units of force and energy which are in no useful ratios to those used in other departments of science, and by people at large. Is there not some way of avoiding this great evil? Societies are formed and sustained whose main and most worthy object is to get rid of such confusions. We think the proposed units should be stoutly challenged to show a necessity for their being.

We do need, it may be added, a new *name* for the earth's attraction upon a gram of matter at some fixed place. The words *gram*, *pound*, *ton*, etc., have had to do service in two different senses, that is, as mass, and as force. If any good word could come into use that shall express the earth's attractive force for a gram of matter at some place that may be agreed upon, it would meet a real want.—H. A. N.]

II. Geology and Natural History.

1. *Some of the Geological views of Hutton.*—The following paragraphs are cited from an Inaugural Lecture by Archibald Geikie, Professor of Geology and Mineralogy in the University of Edinburgh. 1871.—Hutton felt, as Steno and Moro had done, that the earthquake and volcano were but parts of the general mechan-

* Mr. Stoney, who is a member of the Committee, urges the meter instead of the centimeter as the unit of length to serve as base of the system. He says the centimeter "is far too small, and its multiples and submultiples cannot be briefly designated. From its being too small, it, in conjunction with the gram and second, lands us in quite out-of-the-way mechanical units—the unit of force which results being but little more than the pressure of a milligram, and the unit of work being but little more than the hundred thousandth part of a grammeter. This I deem a very serious objection.

"I still think that these awkward consequences, and the footing which the meter has already gained in science, will prove fatal to the recommendation of the Committee, and that experience will show that the meter must in the end be accepted as the standard unit of length."

ism of our planet. But he saw, also, that they were not the only exhibitions of the potency of subterranean agencies, that, in fact, they were only partial and perhaps even secondary manifestations of the influence of the great internal heat of the globe, and that the full import of that influence could not be understood unless careful study were given also to the structure of the rocky crust of the earth. Accordingly he set himself for years patiently to gather and meditate over data which would throw light upon that structure and its history. The mountains and glens, river-valleys and sea-coasts of his native country, were diligently traversed by him, every journey adding something to his store of materials, and enabling him to arrive continually at wider views of the general economy of nature. At one time we find him in a Highland glen searching for proofs of a hypothesis which he was convinced must be true, and, at their eventual discovery, breaking forth into such gleeful excitement that his attendant gillies concluded he must certainly have hit upon a mine of gold. At another time we read of him boating with his friends Playfair and Hall along the wild cliffs of Berwickshire; again, in search of confirmation to his views, and finding, to use the words of Playfair, "palpable evidence of one of the most extraordinary and important facts in the natural history of the earth."

As a result of his wanderings and reflection, he concluded that the great mass of the rocks which form the visible part of the crust of the earth was formed under the sea, as sand, gravel, and mud are laid down there now; and that these ancient sediments were consolidated by subterranean heat, and, by paroxysms of the same force, were fractured, contorted, and upheaved into dry land. He found that portions of the rocks had even been in a fused state; that granite had been erupted through other stony masses; and that the dark trap-rocks, or "whinstones" of Scotland, were likewise of igneous origin. * * * *

Hutton maintained that the combined influence of subterranean heat and pressure upon sedimentary rocks could consolidate and mineralize them, and even convert them into crystalline masses. He was thus the founder of the modern doctrines of metamorphism regarding the gradual transformation of marine sediments into the gnarled and rugged gneiss and schist of which mountains are built up. Let me quote the eulogium passed upon this part of his work in an essay by M. Daubrée, which eleven years ago was crowned with a prize by the Academy of Sciences at Paris:—"By an idea entirely new, the illustrious Scottish philosopher showed the successive coöperation of water and the internal heat of the globe in the formation of the same rocks. It is the mark of genius to unite in one common origin phenomena very different in their nature." "Hutton explains the history of the globe with as much simplicity as grandeur. Like most men of genius, indeed, who have opened up new paths, he exaggerated the extent to which his conceptions could be applied. But it is impossible not to view with admiration the profound penetration and the strictness of induction of so clear-sighted a man, at a time when exact observations had been so few, he being the first to recognize the simultaneous effect of water and heat in the formation of rocks, in imagining a system which embraces the whole physical system of the globe. He established principles which, in so far as they are fundamental, are now universally admitted." * * * *

Hutton first caught the meaning of that constant circulation of water which, by means of evaporation, winds, clouds, rain, snow, brooks, and rivers, is kept up between land and sea. He saw that the surface of the dry land is everywhere being wasted and worn away. The scarped cliff, the rugged glen, the lowland valley, are each undergoing this process of destruction; wherever land rises above ocean, there, from mountain-top to sea-shore, degradation is continually going on. Here and there, indeed, the débris of the hills may be spread out upon the plains; here and there, too, dark angular peaks and crags rise as they rose centuries ago, and seem to defy the elements. But these are only apparent and not real exceptions to the universal law, that, so long as a surface of land is exposed to the atmosphere, it must suffer disintegration and removal.

But Hutton saw, further, that this waste is not equally distributed over the whole face of the dry land. He perceived that while, owing to the greater or less resistance offered by different kinds of rocks, the rate of decay must vary indefinitely, the amount of material must necessarily be greatest where the surplus water flows off toward the sea, that is, along the channels of the streams. Water-courses, he argued, are precisely in the lines which water would naturally follow in running down the slope of the land from its water-shed to the sea, and which, when once selected by the surplus drainage, would necessarily be continually widened and deepened by the excavating power of the rivers. Hence he regarded the streams and rivers of a country as following the lines which they had chiselled for themselves out of the solid land; and thus he arrived at the deduction that valleys have been, inch by inch and foot by foot, dug out of the solid framework of the land by the same natural agents—rain, frost, springs, rivers—by which they are still made wider and deeper. "The mountains," he said, "have been formed by the hollowing out of the valleys, and the valleys have been hollowed out by the attrition of hard materials coming from the mountains." This is a doctrine which is only now beginning to be adequately realized. Yet to Hutton it was so obvious as to convince him, to use his own memorable words, "that the great system upon the surface of this earth is that of valleys and rivers, and that, however this system shall be interrupted and occasionally destroyed, it would necessarily be again formed in time, while the earth continued above the level of the sea."

2. *On the Topography and Geology of Santo Domingo;* by William M. Gabb. 260 pp. 4to, with a map. From the Transactions of the American Philosophical Society, vol. xv.—Mr. Gabb

here presents the results of his investigations during three years residence in San Domingo, comprising facts relating to the topography and geology of 15,000 square miles, or about half the island. He states that the only fossiliferous rocks of the island, besides the Quaternary, are the Cretaceous, which are all more or less metamorphic, and the Tertiary. Along the central portions of the island there are crystalline rocks, which he groups under the generic term of *Syenite*, since they almost invariably consist of the three essential minerals, quartz, feldspar and hornblende. They are pronounced intrusive. Flanking the Cretaceous slates, etc., of the Sierra, there is a broad development of Tertiary along the northern, and part of the southern, side of the island.

The metamorphic rocks referred to the Cretaceous are much upturned and folded, the axes of the folds usually east and west, or parallel with the axis of the mountains. The rocks include, besides the common slates, semi-talcose in aspect, thick strata of sandstones, limestones and conglomerates; but, owing to the disturbed condition of the whole, and the partial obliteration of the bedding in some cases, the order of stratification has not been made out. The reference of them to the Cretaceous is sustained by the discovery, at a few points, of species of *Ostrea*, *Trigonia*, *Ammonites*, and some other genera, which appear to be of Cretaceous character.

The Tertiary of the island is referred to the Miocene period; about thirty per cent of the shells belong to living species. The beds in general lie nearly horizontally over the Cretaceous, but in some places are highly tilted. In the middle of the Santiago valley the height of the beds—there horizontal—is about 200 feet, and, in the hills south of Samana bay, 300 to 400 feet; but, further north, they have been elevated along a line a hundred miles in length, with some upturning, to a height in some cases of 3000 feet or more, "making the Monte Christi Chain, where, until the end of the Miocene, had been a level sea-bottom, covered with white calcareous mud." A large number of Miocene fossils are described by Mr. Gabb. In connection with the account of the Quaternary, Mr. Gabb describes a chalk-like rock, which is of Coral origin. As it is not derived from the accumulation of Rhizopods, like true chalk, he has named the soft rock *Antillite*. The above are a few facts from this important memoir.

3. *Trachytic and doleritic rocks in alternations in the Puebla Range of mountains, in the northern part of Humboldt county, Nevada;* by James Blake, M.D.—Dr. Blake describes the Puebla Mountains as consisting of an eastern ridge of upturned metamorphic rocks, having the strike N. 16° E. and dip 78° to the eastward; and a western ridge formed of beds of eruptive rocks dipping 20° to the westward. The latter are all conformable from the base to the summit, 1200 feet above, and vary in thickness from 20 to 50 or more feet. The eruptions are stated by Dr. Blake to be probably early Miocene. The rocks of the beds are of both the doleritic and trachytic kinds. They include the varieties of

dolerite, called basalt and anamesite, the chrysolitic kind or peridotite, and the chloritic kind called diabase; and, in alternations with these, trachyte; and toward the top vesicular trachyte and porphyritic obsidian. In a porphyritic dolerite the crystals of labradorite are an inch long, and often twins; and the augite is sometimes in crystalline plates. Magnetite is present in most of the rocks in minute grains or crystals. Several of the rocks have been analyzed: the porphyritic dolerite afforded 49 per cent of silica; the anamesite, 44 per cent; the diabase, 51 per cent; the green trachyte, 72 per cent. Dr. Blake concludes from the facts that the views of Richthofen with regard to the relative ages of the different kinds of eruptive rocks will not apply to those of the Puebla Mountains.

Dr. Blake further states that the valley between the two ridges of the Puebla Range has suffered much erosion, and that at one time it must have been filled by a vast glacier which flowed out over the southern part of the eastern range, and left a moraine 250 feet thick, that extends a mile and a half into the plain beyond the base of the mountain.—*Proc. Calif. Acad. Sci.*, v, 210.

4. *Bulletin of the United States Geological and Geographical Survey of the Territories.* Department of the Interior. No. I. 28 pp. 8vo. Washington, 1874.—The Department of the Interior has adopted the excellent plan of issuing in parts, called Bulletins, special portions of the coming Annual Report of the Geological and Geographical Survey of the Territories—the survey now carried forward by F. V. Hayden as U. S. Geologist in charge, and J. T. Gardner, Geographer. This first number of the series, after giving a list of the officers of the expedition for the past year, and another of former publications by the Survey, presents a Report by E. D. Cope "on the Stratigraphical relations and Vertebrate paleontology of the formations which represent the Pliocene epoch in Northeastern Colorado." This Report enumerates the species of Pliocene vertebrates observed in Colorado by the author, during the year 1873, and gives descriptions of the larger part of them. They include 4 Carnivores; 7 Perissodactyls (2 species of *Aphelops*, 2 of *Hippotherium*, 3 of *Protohippus*); 7 of Artiodactyls (2 of *Merichyus*, 4 of *Procamelus*, 1 of *Merycodus*); the Proboscidian, *Mastodon proavus* Cope (of the type of the *Mastodon Americanus*); and the Testudinate, *Stylemys? Niobrarensis* Leidy. Next follow short notes on other Tertiary Mammals from Colorado: *Menotherium lemurinum* Cope, supposed to be allied to the Lemurs, *Isacis caniculus* Cope, *Hoplophoneus* (*Machærodus*) *oreodontis* Cope, *Poëbrotherium Hallii* Leidy, *P. Wilsonii* Leidy; species of *Hypisodus*, *Hypertragulus*, *Leptomeryx*, *Elotherium* and *Symborodon*. Cope announces that the Pliocene camels of the Rocky Mountain region had a full set of upper incisors.

We have received the following from Dr. Hayden with regard to Bulletin No. 2, which will soon be issued: This number contains a long article by Prof. Cope on the relation of the Cretaceous and Tertiary formations of the West, as indicated by their vertebrate remains, and another on new species of fossil fishes from the Cretaceous of Kansas and the Tertiary of Colorado; an article by Prof. Thomas on new species of Acrididæ; and a paper by Mr. J. T. Gardner on the principal ranges of Mountains surveyed by the party last summer in Colorado, with the elevations and the longitude and latitude of the most prominent peaks, varying from 13,000 to 14,600 feet above sea level. The final maps of the expedition up Snake River, and in Montana, during the year 1872, are now engraved on a scale of five miles to one inch; they will be published both as topographical and geological maps. Maps of the Upper and Lower Geyser Basins, which were carefully surveyed, are engraved on a scale of eight inches to one mile.

5. *The Abrasions of the Continental Shores of Northwest America, and the supposed Ancient Sea Levels;* by GEORGE DAVIDSON (Proc. Calif. Acad. Sci., May 5, 1873).—Mr. Davidson has here brought together many interesting facts with regard to plateaus or benches along the Pacific Coast, north of Cape San Lucas, and has illustrated the facts by a large plate. The article does not admit of condensation, and in this place there is room at present only for this simple mention of his important observations.

6. *Mikrogeologische Studien über das kleinste Leben der Meeres-Tiefgründe aller Zonen und dessen geologischen Einfluss;* von C. G. EHRENBERG. 396 pp. 4to, with 12 plates and a map. (Abh. K. Akad. d. Wiss., Berlin, 1872.)—A review of the vast amount of facts which the author has published respecting the microscopic life of sea-bottoms over the world, together with some additional facts and plates. In connection with the many tables showing the distribution of the species, there are references to the memoirs in which they were severally described.

7. *Ostracoids or Bivalve Entromostraca.*—Professor T. RUPERT JONES has published No. X. of his papers on the Paleozoic Ostracoids in the number for June of the Annals and Magazine of Natural History; and also an article on some species, chiefly Cypridinidæ, of the Carboniferous formations, in the Quarterly Journal of the Geological Society for August, 1873.

8. *Revue de Géologie pour les Années*, 1870 *et* 1871; par M. DELESSE, Ingénieur en Chef des Mines, and M. de LAPPARENT, Ingénieur des Mines. 252 pp. 8vo. Paris. 1872. (F. Savy).—A work for all geologists.

9. *Reports on the Geological Survey of the State of Missouri*, 1855–1871. By G. C. BROADHEAD, F. B. MEEK, and B. F. SHUMARD. Published by authority of the Legislature under the direction of the Bureau of Geology and Mines. 324 pp. 8vo. Jefferson City, Mo., 1873.—This volume contains the Reports of geological work done in Missouri, by State authority, previous to the organization of last year, under Raphael Pumpelly, as geologist in charge. The several chapters treat of the local geology of the State to which they are important contributions. They include

Reports of twenty counties, six by Mr. Broadhead, three by Mr. Meek, and eleven by Mr. Shumard, some of which are illustrated by maps and sections.

10. *On Nick-liferous Sand from Frazer River;* by James Blake, M.D.—This sand, which was obtained in the gold washings on Frazer River, has very much the appearance of small particles of iron pyrites, being of decidedly a yellowish color. Under the microscope it is found to consist of two distinct substances, one of which is evidently magnetic oxide of iron, or the common black sand of our gold deposits; the other is of a yellow color, in the form of small scales, without any well marked crystalline structure, and with the edges rounded by abrasion. The whole of the sand is strongly magnetic, so that with the exception of a few scales of gold, it contains nothing that is not taken up by the magnet. An analysis of the sand shows that it consists wholly of the oxides of nickel and iron. 0·9153 grains of the sand yielded 0·256 sesquioxide of iron, and 0·6548 oxide of nickel, which would give, supposing the iron to be in the state of magnetic oxide, 0·231 of oxide of iron; and, if we suppose an analogous oxide of nickel to exist, we should have 0·702 of the magnetic oxide of nickel; thus making 0·931 instead of 0·9153 the quantity used, the excess of 0·016 being undoubtedly due to the nickel, from the difficulty of freeing it completely from the potash with which it is precipitated.

Although I can find no mention of such a compound of nickel, either in Watts' Dictionary of Chemistry, or in Dana's Mineralogy, yet I have no doubt that the form in which the nickel exists in this sand is an oxide with the composition Ni^3O^4, analogous to the magnetic oxide of iron, Fe^3O^4, thus establishing another relation between the compounds of nickel and iron. From the large proportion of it in the sand, fully 75 per cent, it is strange that its presence has not been before noticed.—*Proc. Calif. Acad. Sci.*, v, 200.

11. *Kjerulfine.*—F. v. Kobell has given this name to a new fluophosphate from Bamle in Norway. It is described as compact, with an imperfect cleavage in two directions nearly at a right angle. The fracture is uneven and splintery; luster oily; color faint red to yellow, in thin fragments translucent. G.=3·15. H.=4–5. When heated phosphoresces with a white light. B.B. fuses easily at 3 with intumescence to a blebby enamel. Soluble in hydrochloric acid, but with greater readiness in nitric acid. With sulphuric acid, hydrofluoric acid is evolved and sulphate of lime separates from the solution. Analysis gave

$\ddot{\bar{P}}$	$\dot{Mg}$	$\dot{Ca}$	$\dot{Na}$	$\dot{K}$	Fl	$\ddot{Si}$	$\bar{Al}$ $\bar{Fe}$	$\dddot{S}$
42·22	37·00	7·56	1·56	*tr.*	4·78	1·50	5·40	*tr*=100·02

Excluding the silica and alumina and the oxygen of the lime and soda and averaging the analysis up to 100, von Kobell considers pure kjerulfine to consist of $\ddot{\bar{P}}$ 46·62, $\dot{Mg}$ 40·86, Ca 5·96, Na 1·28, Fl 5·28, from which he calculates the formula to be $2\dot{Mg}^3\ddot{\bar{P}}+Ca\,Fl$, in which a small portion of the calcium is replaced by sodium. This result very nearly approaches the composition of wagnerite, but according to recent analyses of v. Kobell (Sitz. Münch. Akad., May, 1873), the latter contains

$$\dddot{\bar{P}}\ 45{\cdot}70,\ \dot{M}g\ 37{\cdot}18,\ Na\ 3{\cdot}97,\ Ca\ 1{\cdot}81,\ Fe\ 11{\cdot}34,$$

which shows wagnerite to be richer in fluorine and soda than kjerulfine.—*Sitzung Münch. Akad.*, March, 1873.

12. *Tschermakite, a new feldspar.*—Associated with the kjerulfine above mentioned, von Kobell subsequently found another new mineral, a magnesia-soda feldspar, which he has named Tschermakite. This occurs massive, with two cleavages at an angle of 94°. The more perfect cleavage has fine striations, resembling those common in triclinic feldspars. Luster highly vitreous, almost adamantine; color grayish white, translucent to semi-transparent. H. =6. G. =2·64. The mineral phosphoresces with a white light on heating. B.B. fuses quietly at 3 to a translucent glass. In the closed tube gives off water. Not appreciably attacked by acids, but on boiling for a long time with hydrochloric acid the solution reacts for alumina and magnesia. Analysis gave

$\ddot{\bar{S}}i$	$\ddot{\bar{A}}l$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
66·57	15·80	8·00	6·80	*tr.*	2·70=99·87

from which, assuming the water to be basic, v. Kobell gives the ratio of oxygen for $\dot{R}$, $\ddot{\bar{R}}$, $\ddot{S}i$ 1 : 1 : 5. Named after G. Tschermak of Vienna.—*Sitzung Münch. Akad.*, Dec., 1873.

13. *Sphœralcea acerifolia* of Nuttall, a very conspicuous Malvaceous plant of the Rocky Mountain region and Oregon, has been found by Mr. E. J. Hill on an island in the Kankakee River (a tributary of the Illinois), in the northeastern part of Illinois. Unexpected as this discovery is, it is not difficult to see how the species may have got there. A good many northwestern plants occur on the shore of the southern end of Lake Michigan, evidently through water transport. Some of these may have come in recent times, although this could not be inferred simply from the fact that they have not been noticed until lately. Here is one which probably came so long ago as when Lake Michigan discharged into the Mississippi, the lower part of the Kankakee River being in the direct course of the discharge. The present plants may more probably be regarded, not as chance stragglers, but as lingering remnants indicating an ancient habitat. A. G.

14. *Necrology of Botanists.*—The list of botanists deceased during the past year is not a long one; indeed, it includes no name of sufficient mark in the Old World as to call for notice here; but the loss in the United States is heavy, unprecedented, and irreparable.

John Torrey died on the 10th of March, 1873, in the 77th year of his age. This Journal has published a short notice and a fuller biography of Dr. Torrey; the latter forming a part of the Council of the American Academy's Report, May, 1873.

William S. Sullivant, of Columbus, Ohio, died on the 30th of April last, at the age of 70 years. A biographical notice of this eminent muscologist was duly published in this Journal,—from the same Report to the American Academy of Arts and Sciences.

Elias Durand died, at Philadelphia, August 14, 1873, in the 80th year of his age. A notice of him appeared in the September number of this Journal; and much fuller accounts of his life and services have been published in Philadelphia.

John Lewis Russell, of Salem, Mass., died on the 7th of June, in the 65th year of his age. Although he published little besides some contributions to the journals, and for several years was incapacitated by illness, he was an acute botanist, especially in the Cryptogamic department, in which his knowledge of New England plants was critical and extensive.

Henry James Clark, lately Professor in the State Agricultural College at Amherst, Mass., who died on the first of July last, at the age of 47, deserves to be enrolled in the list of botanists. Although his high reputation was won in another department, he was an excellent botanist before he became Mr. Agassiz's assistant and gave himself to zoölogical investigation: the present writer was indebted to him for more than one interesting discovery of points of structure. Prof. Clark is thought to have been the ablest microscopic investigator which this country has produced.

Isaac F. Holton, died, at Everett, Mass., January 25, at the age of 61 years. He was a graduate of Amherst College in the class of 1836, of the Union Theological Seminary, New York, and of the Medical College of the same city, where he became known to and formed a life-long friendship with Dr. Torrey. Like him he pursued both chemistry and botany; and he taught both with success, in various schools and other institutions. He was for a few years professor of the natural sciences in Middlebury College, Vermont; afterward a missionary and pastor in Illinois; whence he removed to the vicinity of Boston in the year 1865, and devoted his time mainly to journalism, always, however, keeping up his scientific activity in various fields. His most considerable publication was a thick octavo volume, published by the Harpers, in 1857, and reprinted in London, entitled "New Granada: Twenty Months in the Andes;" being principally a journal of his visit to and travels in that country a year or two previous. It is written with great spirit, and is replete with valuable information. In New Granada, Mr. Holton made a fine botanical collection of about 1800 species, the duplicates of which were distributed among some principal herbaria. Professor Holton's pursuits and tastes were too multifarious, his harmless eccentricities too pronounced, and his life too unselfish for achieving the distinction or the worldly success which he well deserved. His ambition mainly showed itself in his zeal for helping others, and in forwarding their interests without regard to his own. A. G.

15. *The Localization of the Functions in the Brain;* by Prof. FERRIER.—All are agreed that it is with the brain that we feel, and think and will, but whether there are certain parts of the brain

devoted to particular manifestations is a subject on which we have only imperfect speculations or data too insufficient for the formation of a scientific opinion. The general view is that the brain as a whole subserves mental operations, and that there are no parts specially devoted to any particular functions. This has been recently expressed by so high an authority as Professor Séquard. The idea rests chiefly on the numerous facts of disease with which we are acquainted. There are cases where extensive tracts of brain are destroyed by disease, or removed after a fracture, apparently with no result as regards the mind of the individual. Along with these facts we have others which are very curious, and which hardly seem to agree with this doctrine. One of these is that when a certain part of the brain is diseased, in Aphasia, the individual is unable to express himself in words. Other curious phenomena have been well described by Dr. Hughlings Jackson, viz: that certain tumors or pathological lesions in particular parts of the brain give rise, by the irritation which they keep up, to epileptiform convulsions of the whole of one side, or of the arm or leg or the muscles of the face; and from studying the way in which these convulsions show themselves he was able to localise very accurately, the seat of the lesion.

The great difficulty in the study of the function of the brain has been in the want of a proper method. When we study the function of a nerve, we make our experiments in two ways. In the first place, we irritate the nerve by scratching or by electricity, or by chemical action, and observe the effect; and in the second place, we cut the nerve, and observe what is lost. In regard to the brain and nervous system, the method has been almost entirely, until recently, the method of section. It has been stated by physiologists, that it is impossible to excite the brain into action by any stimulus that may be applied to it, even that of an electric current; they have, therefore, adopted the method of destroying parts of the brain. This method is liable to many fallacies. The brain is such a complex organ that to destroy one part is necessarily to destroy many other parts, and the phenomena are so complex that one cannot attribute their loss to the failure only of the parts which the physiologists have attempted to destroy.

About three years ago, two German physiologists, Fritsch and Hitzig, by passing galvanic currents through parts of the brains of dogs, obtained various movements of the limbs, such as adduction, flexion, and extension. They thus discovered an important method of research, but they did not pursue their experiments to the extent that they might have done, and perhaps did not exactly appreciate the significance of the facts at which they had arrived.

I was led to the experiments which I shall have to explain by the effects of epilepsy and of chorea, which have been explained to depend upon irritation of parts of the brain. I endeavored to imitate the effects of disease on the lower animals, and determined to adopt the plan of stimulating the parts of the brain by electricity, after the manner described by Fritsch and Hitzig.

I operated on nearly a hundred animals of all classes—fish, frogs, fowls, pigeons, rats, guinea pigs, rabbits, cats, dogs, jackals, and monkeys. The plan was to remove the skull, and keep the animal in a state of comparative insensibility by chloroform. So little was the operation felt that I have known a monkey, with one side of the skull removed, awake out of the state induced by the chloroform, and proceed to catch fleas or eat bread and butter. When the animal was exhausted I sometimes gave it a little refreshment, which it took in the midst of the experiments.

First, as to the experiments on cats, I found that on applying the electrode to a portion of the superior external convolution the animal lifted its shoulder and paw (on the opposite side to that stimulated) as if about to walk forward; stimulating other parts of the same convolution, it brought the paw suddenly back, or put out its foot as if to grasp something, or brought forward its hind leg as if about to walk, or held back its head as if astonished, or turned it on one side as if looking at something, according to the particular part stimulated. The actions produced by stimulating the various parts of the middle external convolution were a drawing up of the side of the face, a backward movement of the whiskers, a turning of the head, and a contraction of the pupil respectively. A similar treatment of the lower external convolution produced certain movements of the angles of the mouth; the animal opened the mouth widely, moved its tongue, and uttered loud cries or mewed in a lively way, sometimes starting up and lashing its tail as if in a furious rage. The stimulation of one part of this convolution caused the animal to screw up its nostrils on the same side; and, curiously enough, it is that part which gives off a nerve to the nostril of the same side.

Results much of the same character were produced by the stimulation of the corresponding or homologous parts of the rat, the rabbit, and the monkey. Acting upon the anterior part of the ascending frontal convolution, the monkey was made to put forward its hand as if about to grasp. Stimulation of other portions acted upon the biceps, and produced a flexing of the fore-arm, or upon the zygomatic muscles. The part that appeared to be connected with the opening of the mouth and the movement of the tongue was homologous with the part affected in man in cases of Aphasia. Stimulation of the middle temporo-sphenoidal convolution produced no results; but the lower temporo-sphenoidal, when acted upon, caused the monkey to shut its nostrils. No result was obtained in connection with the occipital lobes.

These experiments have an important bearing upon the diagnosis in certain kinds of cerebral disease, and the exact localization of the parts affected. I was able to produce epileptic convulsions of all kinds in the animals experimented upon, as well as phenomena resembling those of chorea or St. Vitus's dance. The experiments are also important anatomically, as indicating points of great significance in reference to the homology of the brain in lower animals and in man, and likewise served to explain some curious forms of expression common to man and the lower animals. The common tendency, when any strong exertion is made with the right hand, to retract the angle of the mouth and open the mouth on the same side, had been stated by Oken, in his Naturgeschichte, to be due to the homology between the upper limbs and the upper jaw; the true explanation being that the movements of the fist and of the mouth are in such close relation to each other that when one is made to act powerfully the impression diffuses itself to the neighboring part of the brain and the two act together.

The experiments have likewise a physiological significance. There is reason to believe that when the different parts of the brain are stimulated, ideas are excited in the animals experimented upon, but it is difficult to say what the ideas are. There is, no doubt, a close relation between certain muscular movements and certain ideas which may prove capable of explanation. This is supported by the phenomena of epileptic insanity. The most important guide on the psychological aspect of the question is the disease known as Aphasia. The part of the brain which is the seat of the memory of words is that which governs the movements of the mouth and the tongue. In Aphasia the disease is generally on the left side of the brain, in the posterior part of the inferior frontal convolution, and it is generally associated with paralysis of the right hand, and the reason might be supposed to be that the part of the brain affected is nearly related to the part governing the movements of the right hand.

It is essential to remember that the movements of the mouth are governed bi-laterally from each hemisphere. The brain is symmetrical, and I hold it to be a mistake to suppose that the faculty of speech is localized on the left side of the brain. The reason why an individual loses his speech when the left side of the brain is diseased is simply this. Most persons are right-handed, and therefore left-brained, the left side of the brain governing the right side of the body. Men naturally seize a thing with the right hand; they naturally therefore use rather the left side of the brain than the right, and when there is disease, there the individual feels like one who has suddenly lost the use of his right arm.

I may, finally, briefly allude to the results of stimulating the different ganglia. Stimulation of the corpora striata causes the limbs to be flexed; the optic thalami produces no result; the corpora quadrigemina produce, when the anterior tubercles are acted upon, an intense dilatation of the pupil, and a tendency to draw back the head and extend the limbs as in opisthotonos; while the stimulation of the posterior tubercles leads to the production of all kinds of noises. By stimulating the cerebellum various movements of the eye balls are produced.

In the discussion which ensued, Dr. Geo. Harley alluded to the effect of mental emotion on the bodily functions, and the possibility of producing disease by simply acting on the nervous system. Referring to phrenology, he said it was one thing to localize function in the interior of the brain, and quite another to specify functions by manipulating the external cranium; and he quoted a saying of Flourens with reference to phrenology: "Les hommes qui la pratiquent sont des charlatans, et les hommes qui la croient sont des imbeciles."

Dr. Carpenter remarked that the great work of the brain is done in the cortical substance, and in Dr. Ferrier's experiments, the first effect of the stimulus is upon that particular substance, producing an intensification of the circulation through it; being in that respect different from the ordinary stimulation of a nerve which acts upon the fibrous substance of the medullary matter of the brain. He had long since expressed his disbelief in phrenology, which maintained that the animal functions were placed at the back of the head, and the intellectual at the front. Dr. Ferrier's experiments tended to show that the real seat of the intellectual functions was in the posterior part of the brain.

Dr. Brunton, however, alluded to the faculty of will and of self-restraint as distinguishing man from the lower animals, and said that this was probably situated in the *anterior* part of the brain. It was noticeable that criminals, who were deficient in that faculty, possessed only a small portion of brain in front of the head.

Prof. Burdon Sanderson said that the stimulus in Dr. Ferrier's experiments was, contrary to Dr. Carpenter's supposition, exactly like the ordinary excitation of a nerve, and that the effect was produced in an extremely short space of time.—*Rep. Brit. Assoc.*, 1873, *Nature, Oct.* 2.

III. Astronomy.

1. *Discovery of a new Planet;* by C. H. F. Peters. From a communication to one of the editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Feb. 19, 1873.—I take pleasure in communicating the discovery last night of a small planet, not among the known ones, as it seems. I succeeded in getting a full set of ring-micrometer comparisons, but, the sky between 3 and 4 o'clock clouding up, I could not accomplish the determination of the comparison star except approximately. The following place of the planet is near within a minute:

$$1874, \text{Feb. } 18, 14^{h} 30^{m} \text{ m. t.} \quad \alpha(135) = 11^{h} 19^{m} 43^{s}; \ \delta(135) = +4° 25'.$$

Its motion seems not much inclined to the parallel. The magnitude I estimated at about 11·2.

2. *Astronomical Society of London.*—The Gold Medal of this Society has been awarded by its Council to Prof. Simon Newcomb, for his tables of Neptune and Uranus and his other mathematical works.

3. *Academy of Sciences at Paris.*—In the section of *Astronomy*, of the French Academy, Dr. Huggins has been elected to replace M. Petit, and Mr. Newcomb, to replace M. Valz.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Direction of Frost-striations in Mud;* Rev. F. R. GOULDING. (Extracts from a communication dated Roswell, Cobb Co., Georgia.)—I ask the privilege of calling attention to a natural phenomenon which has long enlisted my interest and that of a few others, but which remains, so far as known, without explanation. It is that of slight but plainly marked striations of the soil after a freezing, looking as if a very light harrow had been drawn over it from northwest to southeast, leaving irregular furrows, varying from half an inch to an inch and a half, in depth, and from center to center.

My attention was first drawn to it in 1854, in upper Georgia, during and after the thawing of an extensive and severe "black frost."

After residing for ten years in a region where there were no *black frosts*, and of course no striations, I returned to the mountains of Georgia, and was soon reminded of former observations, by seeing the soil of my garden very deeply marked, the same way as before, during, or rather toward the close of a hard freezing. This place is about forty miles distant from the other, and the soil wholly different, that being limestone and this granite. These striæ invariably run from northwest to southeast, and this is so in shaded as in sunny places, and whether the wind at the time blew, or whether the air was still. They begin to appear before the frozen surface has thawed. Further, the direction is at right angles to the stratification of the country, the outcroppings of the rocks being here in a line from northeast to southwest. If this coincidence be connected with the cause of the striations, it is in some way beyond the ken of us the observers. The writer would be glad to receive any facts that will prove whether any uniformity of direction is observable elsewhere, and that will, if so, lead to its explanation.

2. *The New Chemistry;* by JOSIAH P. COOKE, Jr. 326 pp. 12mo. New York. *The International Scientific Series.* (D. Appleton and Company).—Prof. Cooke, in this volume, presents his readers with a lucid and logical discussion of the principles of Chemical Philosophy in a series of thirteen lectures: 1. Molecules and Avogadro's law; 2. The molecular condition of the three states of matter—the gas, the liquid, and the solid; 3. How molecules are weighed; 4. Chemical composition—analysis and synthesis—the atomic theory; 5. Elementary substances and combining proportions; 6. Atomic weights and chemical symbols; 7. Chemical reactions; 8. Chemical changes classified; 9. The theory of combustion; 10. Gunpowder and Nitro-glycerine; 11. Quantivalence and metathesis—alkalies and acids; 12. Electro-chemical theory; 13. Isomerism, and synthesis of organic compounds. These lectures were delivered before the Lowell Institute, in Boston, in the autumn of 1872, and the author, in presenting his subject in this volume, has preserved the lecture style, so well adapted to convey clearly to the non-professional, but intelligent, auditor, clear notions of abstract ideas. Prof. Cooke's style is

always attractive from its clearness, precision and polish, and any cultivated person, whether previously acquainted with chemistry or not, can read this discussion of chemical philosophy with both pleasure and profit. It is needless to add that the subject is discussed as its title demands, in the terms of the new chemistry.

3. *Annual Report upon the Geographical and Geological Surveys and Explorations west of the* 100*th Meridian, in Nevada, Utah, Colorado, New Mexico and Arizona;* by GEORGE M. WHEELER, First Lieut. of Engineers, U. S. A. Being Appendix EE of the Annual Report of the Chief of Engineers for 1873. 12 pp. 8vo, with a Map.—From this brief report of Lieut. Wheeler we learn that, while the work in the field will be continued, it is proposed that arrangements should go into effect at once for the publication of the results thus far obtained. The results are of great value, and the publication of them will take six quarto volumes, and a folio atlas 19 inches by 24. Vol. 1 will be occupied with a general account of the expeditions of 1871 and 1872, describing the regions traversed, its industries, the native tribes. The *second* will be geographical; the *third*, meteorological; the *fourth*, geological, it consisting of the finished report of the geological work for the same years, and occupying about 225 pages; the *fifth* paleontological, to be illustrated by numerous plates of new Vertebrate and Invertebrate fossils from the Rocky mountain region, obtained in the years 1871, 1872 and 1873; the *sixth* Natural History. The Geological volume, vol. 4, will contain reports from Messrs. Gilbert, Marvine and Howell.

4. *The Cincinnati Quarterly Journal of Science.* Editor and Proprietor, S. A. MILLER. Vol. I, No. 1, January, 1874. 96 pp. 8vo. Cincinnati, Ohio. ($3.00 per year.)—This first number opens well the new Cincinnati Quarterly Journal of Science. The region from which it is issued is one of unusual interest for its geology, paleontology and natural history, and is a great commercial and educational center for the land, and the Journal should hence be successful. In paleontology, the author occupies several pages of the number with short critical articles; there is also a paper on New Brachiopods by U. P. James, and a translation is given of observations on Fossil Sponges in Rœmer's work on the Silurian Fauna of West Tennessee, besides a reproduction of H. B. Hall's Memoir on Fossil Sponges from the London Geological Magazine. There are also other important papers, most of them cited, which have a more popular character. The Journal is well printed, and has our best wishes for its permanence and wide circulation.

5. *Half Hour Recreations in Natural History; Half Hours with Insects.*—Part V. *Insects of the Garden*, their habits, etc.; by A. S. PACKARD, Jr. 32 pp. 8vo. Boston (Estes & Laureat).—Professor Packard is one of the best of American writers on insects, and has produced here a chapter that all will read with interest. It is the first of twelve parts on the Insects of Gardens.

The Stone Age, Past and Present, by E. B. Taylor, and Theory of a Nervous Ether, by Dr. Richardson, make No. 9 of Estes & Laureat's "Half Hour Recreations in Popular Science."

APPENDIX.

ART. XXVIII.—*Notice of New Equine Mammals from the Tertiary Formation*; by O. C. MARSH.

THE explorations of the Yale College party in the Tertiary deposits of the West, during the past season, brought to light many equine remains; some of which prove to be new, and others throw considerable light on the forms already made known by previous investigations. In the present communication some of the more important results obtained are briefly presented, those relating to the genealogy of the modern horse being of special interest.

Orohippus Marsh.

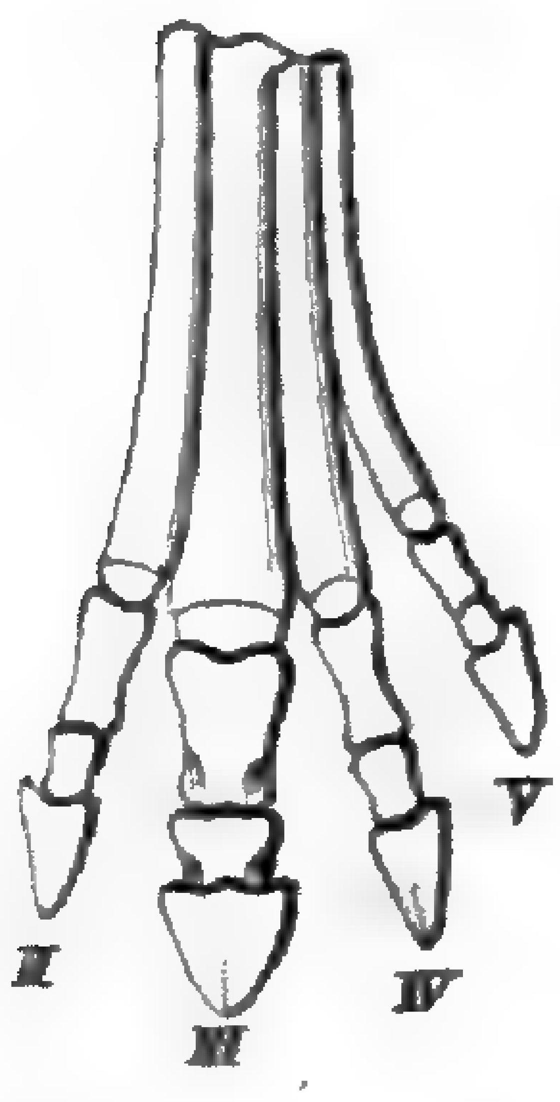
This Journal, iv, p. 207; v, p. 407.

The equine mammals of the American Eocene are at present represented by three species of the genus *Orohippus*, the main characters of which have already been pointed out by the writer. Additional material clears up several doubtful points in its structure. This genus is nearly related to *Anchitherium*, but differs especially in having four functional digits in the manus, and in the absence of an antorbital fossa. The orbit is not enclosed behind. The dentition is very similar to that of *Anchitherium*, but the first upper premolar is proportionally larger, and the succeeding premolars are smaller. The median posterior tubercle of the molars is wanting. The first lower premolar was small, and the rest of the lower molar series closely resemble those in *Anchitherium*. There is long distema. The canine is large, and near the incisors. The crowns of the grinders are very short, and without cement. The dental formula is as follows:

$$\textbf{Incisors}\ \frac{3}{3},\ \textbf{canines}\ \frac{1}{1},\ \textbf{premolars}\ \frac{4}{4},\ \textbf{molars}\ \frac{3}{3}.$$

The skeleton of *Orohippus*, in its general features, is decidedly equine, and this is particularly manifest in the limbs. The scapula has a prominent acromial process, which is compressed and decurved, as in some of the carnivores. The humerus is short and stout. Its head is large, and the bicipital groove narrow and deep. The great tuberosity is elevated, and compressed. The distal end of the humerus is small. The radius and ulna are distinct. The latter is larger than in *Anchitherium*, and entire throughout its whole length. The carpal bones are eight in number, and somewhat similar to those of the Tapir, although the trapezium is proportionally much smaller.

All the digits of the manus, except the first, are well developed, as shown in the accompanying figure of the left forefoot of *Orohippus agilis* Marsh. The third digit is the largest, and its close resemblance to that of the horse is clearly marked. The terminal phalanx, or coffin bone, has a shallow median groove in front, as in many species of this group in the later Tertiary. The fourth digit exceeds the second in size, and the fifth is much the shortest of all. Its metacarpal bone is considerably curved outward. In the pes of this genus, there are but three digits. The fourth metatarsal is much larger than the second. The astragalus has its neck more elongated than in *Anchitherium*, and the face for the cuboid is small. The tibia and fibula are distinct. The cervical vertebræ of *Orohippus* are rather short, and moderately opisthocœlous.



Orohippus major, sp. nov.

The largest species of this genus is indicated by part of an upper jaw with three molars, and the greater portion of a lower jaw with teeth pertaining to another individual. In the former specimen, the intermediate lobes of the molars are less developed than in the species already described, while the anteroposterior buttress is more elevated. The lower jaw is stout, and there is a strong basal ridge on the outer face of the lower molars.

Measurements.

Space occupied by three upper true molars,	24·mm.
Antero-posterior diameter of last upper molar,	8·5
Transverse diameter,	10·
Antero-posterior diameter of penultimate upper molar,	8·5
Transverse diameter,	11·
Extent of four posterior teeth of lower jaw,	33·5
Antero-posterior diameter of last lower molar,	10·5
Transverse diameter,	5·
Antero-posterior diameter of last lower premolar,	7·5
Depth of jaw below middle of this tooth,	14·

This species was about as large as a fox. The remains of it at present known are from the Eocene of Wyoming.

The animals of this genus constitute a distinct family that may be called *Orohippidæ.* The other known species are as follows:

Orohippus gracilis Marsh.

(*Anchitherium gracile* Marsh;) this Journal, ii, p. 38, 1871.

Orohippus pumilus Marsh.

This Journal, iv, p. 207, 1872. (? *Helotherium procyoninum* Cope, Proc. Am. Phil. Soc., xii, p. 466, Feb., 1873.)

Orohippus agilis Marsh.

This Journal, v, p. 407, 1873.

All the animals of this genus now known were quite diminutive, the largest hardly exceeding a fox in size. They are all from the Eocene of Wyoming and Utah.

***Miohippus annectens*, gen. et sp. nov.**

The present genus represents an intermediate form between *Orohippus* and *Anchitherium.* It differs from the former in having but three digits in the manus, and from the latter in the absence of an antorbital fossa, and in the more complete separation of the intermediate lobes of the upper molars. Its dental formula is apparently the same as *Orohippus.* The incisor teeth are small, and the canines large, those below being close to the incisors. The first upper premolar is of moderate size, and the second larger than the last true molar. In the upper molars, the basal ridge rises into a tubercle near the middle of the anterior border. The premaxillaries are slender. The radius and ulna are free, or only loosely united, but the fibula is fused to the tibia at its distal end. The second and third cuneiform bones are distinct. There are three digits in the manus, and three in the pes, all of which reached the ground. They appear to have been more nearly of equal size than in *Anchitherium.*

In the present species the orbit is large, and its anterior margin is directly above the front of the last upper molar. The first upper premolar had two fangs. The enamel of all the teeth preserved is quite smooth. The upper premolars and most of the molars have a prominent compressed tubercle between the inner cusps, but no inner basal ridge. This species differs widely from any hitherto described, with the possible exception of *Anchitherium Condoni* Leidy.* The latter species was founded on an imperfect upper molar tooth, which probably belongs to the genus *Miohippus.* The enamel of this molar is quite rugose, the small cusp behind the posterior crest is parallel with the posterior basal ridge, and the inner tubercle between the transverse crests is entirely wanting. This tooth

* Proc. Acad. Nat. Sci. Philadelphia, 1870, p. 112.

is also proportionally broader than the corresponding teeth of the present species, and hence the two must be regarded as distinct.

Measurements.

Space occupied by four upper premolars,	61· mm.
Extent of three upper true molars,	46·
Antero-posterior diameter of first upper premolar,	13·5
Antero-posterior diameter of second upper premolar,	19·
Transverse diameter,	18·
Antero-posterior diameter of last upper molar,	14·
Transverse diameter,	19·5
Length of calcaneum,	68·
Length of astragalus,	32·
Antero-posterior diameter of tibia at distal end,	26·
Transverse diameter,	33·

All the known remains of this species are from the Miocene of Oregon. They indicate an animal somewhat exceeding a sheep in size, and with longer limbs.

Anchitherium anceps, sp. nov.

The Miocene deposits of Oregon contain another species of solipeds, smaller than the one just described, and apparently belonging to the genus *Anchitherium.* The skull has a large antorbital fossa, and the molar teeth agree essentially with those of that genus. The limbs, so far as known, were also similar. The first upper premolar has two fangs, and is well developed. The infra-orbital foramen is above the center of the third premolar. The present species most nearly resembles *Anchitherium Bairdi* Leidy, from the Miocene east of the Rocky Mountains. It differs, however, aside from the larger size, in the following particulars: the skull is depressed between the orbits; the molar teeth extend farther back below the orbit; the external cusps of the upper molars have their buttresses much stouter, and the concavities between them divided by more prominent vertical ridges.

Measurements.

Space occupied by four upper premolars,	47·5 mm.
Antero-posterior diameter of first upper premolar,	9·
Antero-posterior diameter of second upper premolar,	13·
Transverse diameter,	13·
Antero-posterior of last upper premolar,	13·
Transverse diameter,	15·5
Antero-posterior diameter of last lower molar,	17·
Transverse diameter,	8·
Extent of upper molar series (second specimen),	82·
Extent of three upper true molars,	37·

The remains of this species indicate an animal about as large as a sheep. The specimens on which the above description is mainly based, were presented to Yale College Museum by the Rev. Thomas Condon, of Oregon.

Anchitherium celer, sp. nov.

The smallest species of *Anchitherium* from the American Tertiary is indicated by some fragmentary remains in the Yale Museum, from the Miocene of Nebraska. These fossils pertain to a fully adult animal, which was about two-thirds the size of *Anchitherium Bairdi*. The orbit is placed well forward. The ridge below it is especially prominent, and much elevated above the molar teeth. The crowns of the latter are remarkably short. The four posterior molars have their inner margins on a line. The last upper molar is quite small.

Measurements.

Space occupied by last four upper molars,	37· mm.
Extent of three upper true molars,	27·
Antero-posterior diameter of last upper premolar,	10·
Transverse diameter,	13·
Antero-posterior diameter of last upper molar,	8·5
Transverse diameter,	12·
Distance of lower margin of orbit above last upper molar,	20·

The type specimen of the species was presented to Yale College Museum by Capt. W. A. Jones, of the U. S. Engineers.

Protohippus parvulus Marsh.

(*Equus parvulus* Marsh, this Journal, xlvi. p. 374, 1868.)

A reëxamination of the remains of this species originally described, and of the other fossils found with them, clearly indicates, as at first suspected, that this diminutive animal was not a true *Equus*, and there can now be but little doubt that it belongs in the genus *Protohippus* of Leidy, as at present understood. With the limb bones preserved, an upper molar tooth was found, which doubtless pertained to the same animal, although it is rather larger in proportion than the teeth of some allied species. The crown of this tooth is very short, and the arrangement of the enamel particularly simple. The inner lakes have no folds, and agree in form with those of *Protohippus* (*Merychippus*) *insignis* Leidy. The anterior lake, at its inner posterior angle, is connected by a narrow outlet with the main transverse valley. The inner anterior column is a broad oval in outline, and is connected with the antero-median column. This molar is from near the middle of the series, and measures 15mm. antero-posterior diameter. Other fragmentary teeth indicate that the incisors were very small, and the canines large.

The bones of the feet preserved, which may with considerable certainty be referred to the same individual, imply that the manus and pes had the lateral digits developed, as in *Hipparion*.

The known remains of this species indicate an animal about two and a half feet in height. The specimens described are from the Pliocene beds at Antelope Station, Nebraska. Other remains of the same species were found by the writer, last year, on the Niobrara River, in the same geological horizon.

Pliohippus pernix, gen. et sp. nov.

A new genus of solipeds, allied to *Equus*, is well represented in the Yale Museum by two partial skeletons, with the more important portions preserved, and by numerous fragmentary remains. This genus closely resembles *Protohippus* Leidy in its dentition, but differs in the absence of lateral digits, which are only represented by slender splint bones. From the true *Equus*, the present genus may be distinguished by the presence of a large antorbital fossa; by the functional first upper premolar; and by a different composition of the crowns of the upper molars. The dental formula of *Pliohippus* is as follows:

$$\text{Incisors } \frac{3}{3}, \text{ canines } \frac{1}{1}, \text{ premolars } \frac{4}{3}, \text{ molars } \frac{3}{3}.$$

The incisors have the characteristic pit of the modern horse. The molars have short crowns, with distinct fangs. The skull is comparatively short, and the orbit is closed behind. The ulna is not entire, and its extremities are ankylosed to the radius. The distal end of the fibula has coalesced with the tibia. On the radial side of the carpus, there is a small ossicle which appears to represent the trapezium. On the opposite side, attached to the unciform, there was a rudiment of the fifth metacarpal.

The present species was about the size of the ass. The skull is larger, and has a deep irregular fossa in front of the orbit. The molar teeth have very short crowns, and long fangs. The folds of the enamel are very simple, and there are none in the inner lobes. The limbs were slender, and more elongated than in the ass. The ungual phalanges are broader, and slightly cleft at their extremities. The femur has the fossa above its outer condyle unusually deep. The cuboid facet on the astragalus is larger than in most equines.

Measurements.

Extent of four upper premolars,	88. mm.
Antero-posterior diameter of first upper premolar,	13.
Antero-posterior diameter of second premolar,	31.
Extent of three upper true molars,	68.
Antero-posterior diameter of last upper molar,	28.
Extent of lower molar series,	146.
Extent of last three lower molars,	72.
Length of radius,	253.

Width of proximal end,	49· mm.
Width of articulation of distal end,	40·
Length of third metacarpal,	189·
Length of first phalanx of third metacarpal,	55·
Length of second phalanx,	25·
Length of third phalanx,	38·
Width of third phalanx,	50·
Length of calcaneum,	77·
Length of astragalus,	41·
Length of third metatarsal,	208·

The specimen here described was exhumed by the writer, in June last, from the Pliocene sands of the Niobrara River, Nebraska.

Pliohippus robustus, sp. nov.

A second species of the genus *Pliohippus* is indicated by part of a skeleton with portions of the skull and teeth of one individual, and apparently by fragments of others. This species was nearly the same size as that last described, but the limbs were shorter and stouter. The first upper premolar is much larger, and the upper molars are longer, and much curved. The crowns of these teeth have a very similar arrangement of the enamel, but the folds are more complex.

Measurements.

Extent of four upper premolars,	98· mm.
Antero-posterior diameter of first upper premolar,	18·
Antero-posterior diameter of second premolar,	29·
Extent of three upper true molars,	73·
Transverse diameter of humerus at distal end,	54·
Transverse diameter of radius at proximal end,	50·
Transverse diameter of distal end,	50·
Length of third metacarpal,	178·
Width of proximal end,	33·
Width of distal articular face,	29·
Length of first phalanx of third metacarpal,	54·
Length of second phalanx,	30·
Length of third phalanx,	36·

The known remains of this species were found by the writer, last summer, in the Pliocene strata of the Niobrara River.

Protohippus avus, sp. nov.

A number of teeth from the Pliocene beds of Oregon indicate a well marked species, which may provisionally be placed in the genus *Protohippus*, although they differ so widely from those already described that additional remains will probably prove them to be generically distinct. The most of these specimens are apparently all from one individual, and consist of a nearly complete series of upper and lower molars, and one incisor. The molar teeth have very short crowns, and are inserted by distinct fangs. The enamel is covered with a thick coat of cement. The molars are considerably worn, and the pattern of the enamel thus produced nearly resembles that in the corresponding teeth of *Anchitherium*, with which the present teeth agree, also, in form and arrangement. The main peculiarity of the upper molars is, that in all of them the anterior lake opens into the transverse valley, while the outer lake is distinct, and much contracted. The outer concavities of the external lobes are without any median elevation. The posterior inner cone is larger than the one in front. All the lower molars have an outer basal ridge. The middle teeth are the largest of the series. The second premolar resembles in form the same tooth in *Anchitherium*, but the anterior buttress is less distinct. There are six lower molars, the last premolar being the largest of the series. The first premolar had its anterior lobe unworn, and much elevated above the level of the grinding surface. The fore and aft diameter of the lower molars is unusually short. The enamel of these teeth is strongly rugose, more so than that of the upper molars.

Measurements.

Space occupied by six upper molars,	110·mm.
Space occupied by three upper premolars,	57·
Antero-posterior diameter of second upper premolar,	23·
Transverse diameter,	22·
Antero-posterior diameter of last upper molar,	17·
Transverse diameter,	22·
Extent of three lower premolars,	57·
Antero-posterior diameter of first lower premolar,	20 5
Transverse diameter,	15·
Antero-posterior diameter of first lower true molar,	18·
Transverse diameter,	16·

For the type specimen of the species, I am indebted to Rev. Thomas Condon, of Oregon, who first explored the Pliocene strata of that State.

Anchippus brevidens, sp. nov.

The genus *Anchippus* Leidy was founded on a single upper molar tooth from strata, in Texas, supposed to be Miocene.* Several teeth obtained by the Yale party in the Pliocene of Oregon clearly belong to the same genus, but indicate a distinct species. These teeth agree in the general structure of their crowns with the type of *Anchippus Texanus*, but the antero-median lobe is placed further forward, and hence its worn surface is not in the same line with that of the antero-internal lobe. The posterior crescentoid tubercle, also, is isolated, and

* Proc. Acad. Nat. Sciences, Philadelphia, 1868, p. 231.

wears into an ear-shaped lobe, enclosing a pit filled with cement. The crowns of these molars are unusually short, even when unworn. They all have distinct fangs, and their enamel is covered with cement. The outer lobes have only a faint indication of a median ridge on their concave faces. The buttresses that enclose these faces are prominent.

Measurements.

Antero-posterior diameter of first upper true molar,	17·5mm.
Transverse diameter,	22·
Antero-posterior diameter of last upper molar,	17·
Transverse diameter,	21·5
Height of unworn crown of last upper molar,	15·

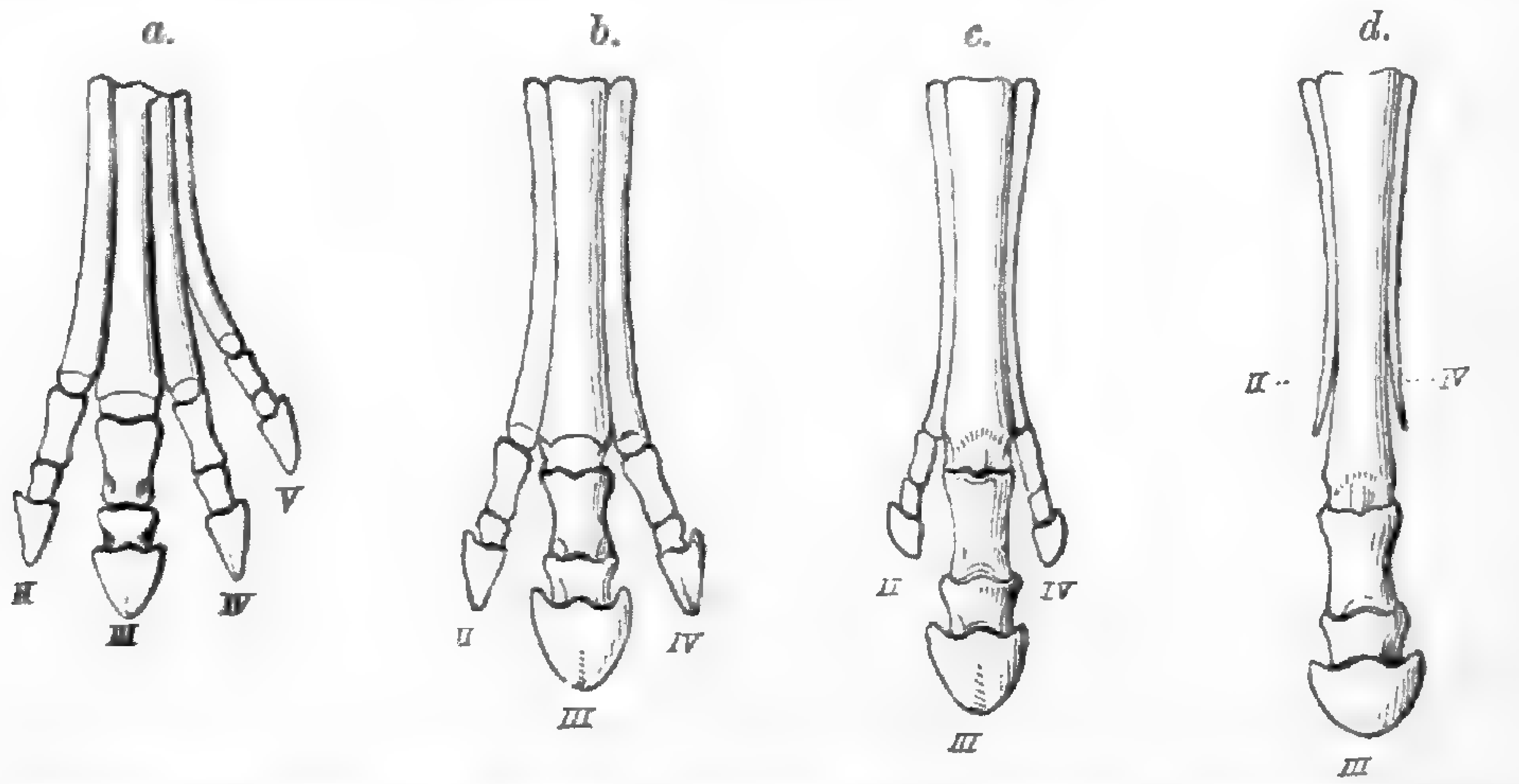
The specimens here described indicate that the genera *Anchippus* and *Hypohippus*, established by Dr. Leidy, are nearly related, and will probably prove to be identical.

The large number of equine mammals now known from the Tertiary deposits of this country, and their regular distribution through the subdivisions of this formation, afford a good opportunity to ascertain the probable lineal descent of the modern horse. The American representative of the latter is the extinct *Equus fraternus* Leidy, a species almost, if not entirely, identical with the old world *Equus caballus* Linn., to which our recent horse belongs. Huxley has traced successfully the later genealogy of the horse through European extinct forms,* but the line in America was probably a more direct one, and the record is more complete. Taking, then, as the extremes of a series, *Orohippus agilis* Marsh, from the Eocene, and *Equus fraternus* Leidy, from the Quaternary, intermediate forms may be intercalated with considerable certainty from the thirty or more well marked species that lived in the intervening periods. The natural line of descent would seem to be through the following genera :— *Orohippus*, of the Eocene; *Miohippus* and *Anchitherium*, of the Miocene; *Anchippus*, *Hipparion*, *Protohippus*, and *Pliohippus*, of the Pliocene; and *Equus*, Quaternary and recent.

The most marked changes undergone by the successive equine genera are as follows: 1st, increase in size; 2nd, increase in speed, through concentration of limb bones; 3d, elongation of head and neck, and modifications of skull. The increase in size is remarkable. The Eocene *Orohippus* was about the size of a fox. *Miohippus* and *Anchitherium*, from the Miocene, were about as large as a sheep. *Hipparion* and *Pliohippus*, of the Pliocene, equalled the ass in height: while the size of the Quaternary *Equus* was fully up to that of the modern horse.

* Anniversary Address, Geological Society of London, 1870.

The increase of speed was equally marked, and was a direct result of the gradual modification of the limbs. The latter were slowly concentrated, by the reduction of their lateral elements and enlargement of the axial one, until the force exerted by each limb came to act directly through its axis, in the line of motion. This concentration is well seen, e. g., in the fore limb. There was, 1st, a change in the scapula and humerus, especially in the latter, which facilitated motion in one line only; 2nd, an expansion of the radius, and reduction of the ulna, until the former alone remained entire, and effective; 3rd, a shortening of all the carpal bones, and enlargement of the median ones, ensuring a firmer wrist; 4th, an increase in size of the third digit, at the expense of those on each side, until the former alone supported the limb. The latter change is clearly shown in the following diagram, which represents the fore feet of four typical genera in the equine series, taken in succession from each of the geological periods in which this group of mammals is known to have lived:



a. Orohippus (Eocene); *b. Miohippus* (Miocene); *c. Hipparion* (Pliocene); *d. Equus* (Quaternary).

The ancient *Orohippus* had all four digits of the manus well developed. In *Miohippus*, of the next period, the fifth toe has disappeared, or is only represented by a rudiment, and the limb is supported by the second, third, and fourth, the middle one being the largest. *Hipparion*, of the later Tertiary, still has three digits, but the third is much stouter, and the outer ones have ceased to be of use, as they do not touch the ground. In *Equus*, the last of the series, the lateral hoofs are gone, and the digits themselves are represented only by the rudimentary splint bones.* The middle, or third, digit supports the limb, and its size has increased accordingly. The corresponding

* The modern horse occasionally has one of the ancestral hooflets developed, usually on the fore foot.

changes in the posterior limb of these genera are very similar, but not so manifest, as the oldest type (*Orohippus*) had but three toes behind. An earlier ancestor of the group, perhaps in the lowest Eocene, probably had four toes on this foot, and five in front. Such a predecessor is as clearly indicated by the feet of *Orohippus*, as the latter is by its Miocene relative. A still older ancestor, possibly in the Cretaceous, doubtless had five toes in each foot, the typical number in mammals. This reduction in the number of toes may, perhaps, have been due to elevation of the region inhabited, which gradually led the animals to live on higher ground, instead of the soft lowlands where a polydactyl foot would be an advantage.

The gradual elongation of the head and neck, which took place in the successive genera of this group during the Tertiary period, was a less fundamental change than that which resulted in the reduction of the limbs. The process may be said to have already began in *Orohippus*, if we compare that form with other most nearly allied mammals. The diastema, or "place for the bit," was well developed in both jaws even then, but increased materially in succeeding genera. The number of the teeth remained the same until the Pliocene, when the front lower premolar was lost, and subsequently the corresponding upper tooth ceased to be functionally developed. The next upper premolar, which in *Orohippus* was the smallest of the six posterior teeth, rapidly increased in size, and soon became, as in the horse, the largest of the series. The grinding teeth at first had very short crowns, without cement, and were inserted by distinct roots. In Pliocene species, the molars became longer, and were more or less coated with cement. The modern horse has extremely long grinders, without true roots, and covered with a thick external layer of cement. The canine teeth were very large in *Orohippus*, and in this genus, as well as those from the Middle Tertiary, appear to have been well developed in both sexes. In later forms, these teeth declined in size, especially as the changes in the limbs afforded other facilities for defence, or escape from danger. The incisors in the early forms were small, and without the characteristic pit of the modern horse. In the genera from the American Eocene and Miocene, the orbit was not enclosed behind by an entire bridge of bone, and this first makes its appearance in this country in Pliocene forms. The depression in front of the orbit, so characteristic of *Anchitherium* and some of the Pliocene genera, is, strange to say, not seen in *Orohippus*, or the later *Miohippus*, and is wanting, likewise, in existing horses. It is an interesting fact that the peculiarly equine features acquired by *Orohippus* are retained persistently throughout the entire series of succeeding forms. Such, e. g., is the form of symphysial part of the lower jaw, and also the characteristic astragalus, with its narrow, oblique, superior ridges, and its small articular facet for the cuboid.

Such is, in brief, a general outline of the more marked changes that seem to have produced in America the highly specialized modern *Equus* from his diminutive, four-toed predecessor, the Eocene *Orohippus*. The line of descent appears to have been direct, and the remains now known supply every important intermediate form. It is, of course, impossible to say with certainty through which of the three-toed genera of the Pliocene that lived together, the succession came. It is not impossible that the later species, which appear generically identical, are the descendants of more distinct Pliocene types, as the persistent tendency in all the earlier forms was in the same direction. Considering the remarkable development of the group throughout the entire Tertiary period, and its existence even later, it seems very strange that none of the species should have survived, and that we are indebted for our present horse to the old world.

Yale College, New Haven, Feb. 20th, 1874.

THE

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JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

Art. XXIX.—*On the great Lava-flood of the Northwest; and on the structure and Age of the Cascade Mountains;* by Joseph LeConte, Professor of Geology, University of California.

[Continued from page 180.]

V. *Some important points suggested by the previous discussion.*

A. *Successive outflows of Cascade lava.*—Mountain-making, whether by the up-swelling of sediments or the out-squeezing of liquid, is probably always a slow process. The latter mode, however, viz: the up-building by out-squeezed matters is probably more paroxysmal than the former. The Cascade Range was probably built up paroxysmally by many successive outflows, occupying a very long period of time. I believe it possible to detect these successive outflows—to detect in its exogenous structure the lines of mountain-growth.

It is well known that columnar basalt, when in thick masses, is often divided into horizontal layers by planes which interrupt the continuity of the vertical columns. Magnificent examples of this structure are found in the basalts of the Cascade Range. On the nearly perpendicular cliffs of Columbia River, ten or twelve horizontal layers may be distinctly counted (figs. 2 and 3), and doubtless many others exist, but their outcropping edges are covered with the products of disintegration. On the perpendicular cliffs of the Des Chutes River (fig. 1), at least twenty layers can be clearly made out, and about ten more with less certainty, on one section. Still higher up on the gentler slope are seen many others, though their out-cropping edges are mostly covered up by debris and soil. That these layers are in some cases really separate flows is shown by the fact that they are separated by volcanic conglomerate or breccia or by partially cemented soil, and are often of different kinds of materials. In other cases it seems doubtful whether they indicate separate flows at all. If they do, the flows must have followed each other in quick succession, each before the previous one had suffered surface disintegration; for the layers, though somewhat distinct, are in solid contact and connection with each other. In the Columbia River Cañon, as at Castle Rock and Cape Horn, and especially in gorges of the tributaries, I found masses of basalt, many hundred feet thick, affected with horizontal layers, but yet very solid throughout.

Again, without doubt, certain lava ridges running from the Cascade crest, and terminating somewhat abruptly against the Des Chutes plains, are separate flows, distinct from each other and from the lava of the Des Chutes plains itself. These enormous ridges are probably flows from distinct fissures. The ridge terminating in Des Chutes Hills (fig. 1) is formed by one of these grand flows, itself composed of many subordinate flows from the same fissure. Mr. Condon thinks that Mutton Mountains on the south, and Klikitat Mountains on the north, and Simcoe Mountains still farther north, were formed by similar flows. The lava of these ridges is entirely different from and more trachytic than that of the plains. Whether the lava of the ridges is older or newer than that of the plains, I am uncertain, but they are more probably older The lava layers of the Des Chutes Hills seem to dip slightly toward the west, as indicated in fig. 1. It seems most probable that the ridges were first formed and disturbed, and then the lava of the plains was poured out and spread about their feet, and finally the river cut its channel 1000 feet deep along the sinuous line of contact between the two.

B. *Relative age of different kinds of lava.*—Without doubt a careful study of the 3500 feet of lava which forms the Cascade Mountains, and which is exhibited in section at the Columbia and Des Chutes Rivers, by one thoroughly versed in the lithology of igneous rocks, would afford a splendid opportunity of testing the truth of Richthofen's view, that there is an invariable order of succession in the appearance at the surface, by fissure-eruption, of the different kinds of lava, the order being, according to him, propylite, andesite, trachyte, rhyolite, basalt.* I confess, however, that my knowledge of the divisions and subdivisions of the species and varieties of volcanic rocks, according to Richthofen's somewhat complex classification, is not sufficient to make my rather hasty observations of much value. Such

* Memoirs of Cal. Acad. of Science, vol. i, pt. 1.

observations as I made, however, I here present merely to draw attention to this important subject.

As I have already said, the sub-lava conglomerate is composed wholly of *porphyritic* pebbles and boulders. I think most geologists would call the material of these boulders and pebbles *porphyry.* I have never seen this rock *in situ*, but it doubtless exists *in situ* beneath the lava. Its position agrees well with the view of Richthofen as well as of most writers, as to the *Mesozoic age of porphyry.*

Again, on the *north* side of the Columbia River gorge, the cliffs are in some places composed, in their *lower* parts, of a whitish or grayish *trachyte*, while their *upper* parts are composed of regular horizontal layers of columnar *basalt.* King also observed the same relation in the trachyte and basalt which forms the cliff of the Snake River Cañon in Idaho; 300 feet of trachyte below and 400 feet of basalt above These facts are also in accordance with Richthofen's view.

But, on the other hand, on the *south* side of the Columbia gorge, columnar basalt forms the whole cliff down to the underlying conglomerate. And at the Dallès I saw tracthyte or trachytic tufa, probably from Mt. Hood, overlying the basalt. And Mr. Condon tells me that while the flows from Mt. Adams are all basalt, those from Mt. Hood, even the latest, are all trachytic. These last facts, however, viz: Mt. Hood trachytic tufa overlying columnar basalt, and the simultaneous ejection of basaltic and trachytic lavas by Mts. Adams and Hood, are by no means fatal to Richthofen's views; since the regular succession of different kinds of lava strictly apply only to *fissure*-eruptions, such as those which form the lava-*layers* of Columbia and Des Chutes Rivers, and not to *crater*.eruptions, such as those which form the lava-*streams* from Mts. Hood and Adams, still less to crater and fissure-eruptions in relation to each other. There is evidently nothing to hinder the supposition that while Mt. Adams may have been, by secondary eruption, ejecting materials from a more superficial basaltic region of Cascade lavas. Mt. Hood has been simultaneously and similarly ejecting materials from a deeper trachytic region.*

C. *Drift covering in Oregon and Washington.*—In nearly all portions of Oregon over which I traveled there is a well-marked superficial boulder drift. Its true nature as a general or northern drift is most conspicuously evident on the dry grassy rolling prairies of the eastern slope of the Cascades, and especially on the extensive level elevated lava-plains lying between the Cascade and the Blue Mountains. This whole region

* In a recent paper read before the California Academy of Science (Proc., vol. v, p. 210). Dr. J. Blake shows that in the Puebla range, Nevada, trachyte overlies basalt in regular layers, indicating true fissure-eruptions.

is covered universally, to a depth of five to thirty feet, with a very fine unsorted earth (a true rock-meal) mixed with *lava pebbles;* the pebbles becoming larger and more numerous in the lower part. We may therefore roughly divide the whole thickness into two layers graduating into each other; a top layer of fine unsorted dirt, and a bottom layer of pebbles and boulders. Over the hilly region of the slopes, the drift covering is thinner, and the two layers somewhat more distinct; over the plains farther east it is thicker, and the two layers graduate into each other.

Over this whole region no *angular erratics*, no moraines nor loose moraine matter, were any where observed. If glacier ice existed, it must have been in the form of a universal ice-sheet mantling the whole surface, and therefore carrying no debris atop. Certainly the drift soil is such as would be produced by moving ice, for every particle of it seemed to have been subjected to the severest attrition, but I looked in vain for glaciated surfaces. Whether any such surfaces on the bed-rock would be exposed by fresh removal of the drift covering, I am unable to say; but certainly I observed none on rocks exposed by natural agencies. The contrast in this respect between this and the high Sierra region visited the previous summer is very striking. If an ice-sheet covered this region, we can only account for the absence of glaciated surfaces by the rapidity with which lava undergoes surface disintegration. I know of no point more important than the careful examination of the surface of the bed-rock in this region. I suspect glaciation would be found. Higher up on the slopes of the Cascade Range, near Mts. Jefferson and the Three Sisters, Newberry observed very decided and unmistakable glaciation.* Even in this high region, however, glaciated surfaces have been rarely observed, either because not looked for sufficiently carefully, or else, as I think, because covered by more recent volcanic ejections.

There is another peculiarity of the Cascade Mountains which I wish to notice. Any one who is familiar with the Sierras, and observed the sharp, jagged, teeth-like outline of its crest, when seen from a distance, cannot but be struck with the comparative tameness and evenness of the outline of the Cascade crest. This is natural enough when we consider the recency, and especially the mode, of its formation, viz., by overflow of liquid materials. But one would suppose that this evenness would have been destroyed by glacial sculpturing. On the contrary, there are in the outlines of the Cascades no marks of separate glaciers lingering until recent times, such as we find at every step in the high Sierras. If the forms of the Cascade Range have been determined by ice, it must have been by an

* Pacific R. R. Report, vol. vi, Geol., p. 32.

NOTE.—The reader will notice an error of 100 in the paging beyond, commencing with this page.—PRINTERS.

ice-mantle, not by separate glaciers. Or else, if separate glaciers existed to any extent, these effects have been obliterated by still more recent volcanic ejections.

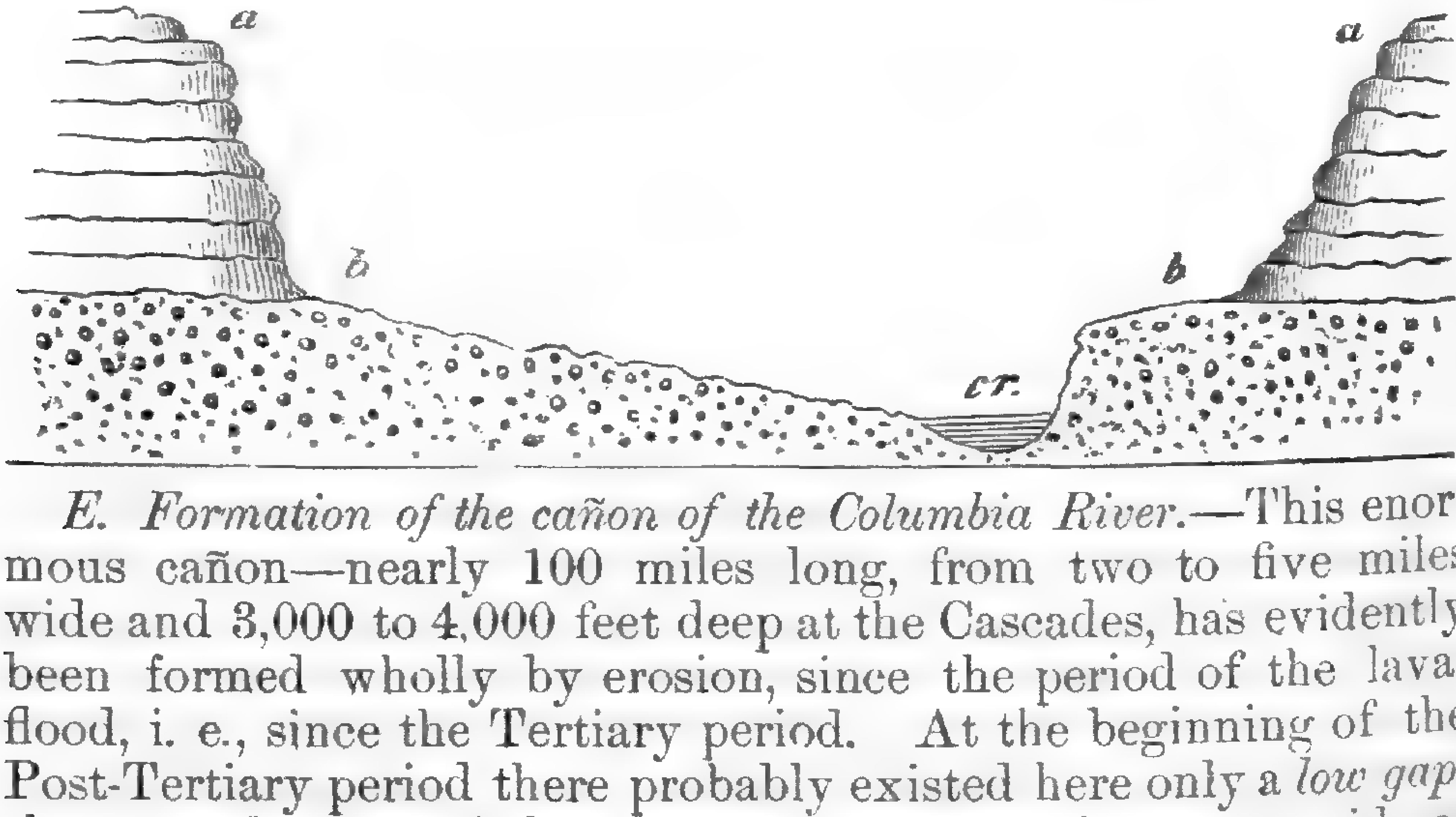
In Washington, the universal drift covering is equally conspicuous, but in addition, erratics often of granite and apparently from the granitic region of British Columbia are not uncommon. Other evidences of glacial action are seen, also, in the deep narrow fiord-like inlets of Puget Sound and along the coast farther north, and in the beautiful glaciation of Vancouver's Island. This island has evidently been completely enveloped in ice and moulded beneath its surface.

D. Oscillations during Post-Tertiary times on the Pacific Coast.—I think there are abundant and unmistakeable evidences of oscillations during the Post-Tertiary period on this coast, somewhat similar to those characteristic of that period on the eastern coast. The subject has been yet, however, but imperfectly studied. I shall only speak of what I saw in Oregon and Washington.

Puget Sound consists of a somewhat intricate system of narrow channels, which in most parts are very deep, even up to the very shore. In other words, it has all the characters of an *intricate system of fiords.* I think there is little doubt that these channels are a system of subaerially eroded valleys which have sunk beneath the sea-level. The erosion may have been produced either by rivers or by glaciers; the latter, however, is more probable, as glacial marks are abundant over the surface of Vancouver's Island. The channels of Puget Sound therefore, I conceive, indicate a former condition *more elevated than the present.* Again, beyond the southern extremity of Puget Sound, there is an intricate system of glades or prairies overgrown with grass and ferns only, ramifying amongst the magnificent dense fir forests of this region. Between the dense forests of firs, 200 feet high, and the absolutely treeless prairies there is the sharpest line of definition. The prairies are slightly lower than the wooded portions, and their relations to the Sound suggest at once that they were at one time irregular southward extensions of the sound, perhaps alternately flooded and left bare by the tides, like the mud-flats about Olympia at the present southern extremity. These prairies, therefore, probably indicate a period of *subsidence* and subsequent *re-elevation.* In a word, we have about Puget Sound evidences of a Glacial, a Champlain and a Terrace Epoch.

In Oregon, the evidences of *elevation* are perhaps less certain. The general drift covering may or may not, according to our theory of its formation, indicate elevation; but the glaciation observed by Newberry certainly indicates greater cold, and therefore probably greater elevation than now. But the evidences of *depression* are of the clearest kind. In an admirable article published in the Overland Monthly (Nov., 1871), and entitled "The Willamette Sound," Mr. Condon traces an old sea- and sound-level, some 300 feet above the *present* sea-level, from the ocean, up the Columbia River, around the great valley of the Willamette and then up the Columbia again to the Dalles. Much of the evidence of this was shown me by Mr. Condon, on my recent visit to Oregon. Here there is undoubted evidence of *depression and re-elevation.* It is generally admitted also, that during the same period, all the flat-lands and valleys about the Bay of San Francisco, and the whole valley of the Sacramento and San Joaquin Rivers was covered with water—the latter forming an immense lake or sound.

7.



E. Formation of the cañon of the Columbia River.—This enormous cañon—nearly 100 miles long, from two to five miles wide and 3,000 to 4,000 feet deep at the Cascades, has evidently been formed wholly by erosion, since the period of the lava-flood, i. e., since the Tertiary period. At the beginning of the Post-Tertiary period there probably existed here only a *low gap*, the natural outlet of the immense basin on the eastern side of the range. If a glacial sheet existed in Eastern Oregon, its only outlet to the sea would have been over this gap. In that case, the principal part of the erosion was produced by ice during the Glacial epoch, and by floods produced by the melting of the receding ice sheet during the Champlain epoch. In any case there can be no doubt of the existence, during Post-Tertiary times, of great bodies of fresh water in Eastern Oregon, and probably of a very moist climate in that now arid region. The drainage of the waters of this immense basin was through the Columbia River gap. The erosion, whether by ice or water or both, during Post-Tertiary times, was certainly very great. I believe the distinction between the enormous Post-Tertiary erosion and the smaller recent erosion is still detectable. Fig. 7 is a diagrammic section across the cañon at the Cascades. Between the high basaltic cliffs *a a*, the distance at the Cascades is at least five miles. This grand cañon, through 3,500 feet of lava down to the conglomerate, was, I think, swept out during the Post-Tertiary either by water or by ice or by both. Since that time the greatly shrunken river has cut its way into the conglomerate *b b*, about 120 feet, moving meanwhile more and more to the south, so as to form perpendicular conglomerate cliffs on that side only. If this lower, narrower conglomerate cañon belongs to the present epoch, then the recession of the perpendicular falls three miles back from the river, as already described in the early portion of this paper, belongs also to the present epoch.

F. Prairie mounds.—The irregularly ramifying grassy glades or prairies already described as existing at the southern extremity of Puget Sound, are studded over as thickly as possible with *mounds* about three to four feet high and thirty to forty feet in diameter at base. For this reason these glades are usually known as "*mound-prairies.*" There are millions of these mounds, and they stand so thickly that they touch each other at their bases, leaving no level space between. Although accurate measurement would doubtless show some variety in shape, size and position, yet the general impression upon the observer is that of perfect regularity. The mounds themselves consist wholly of a drift soil of earth, gravel and small pebbles: the intervals between are thickly strewn with larger pebbles and small boulders. The vegetation of the mounds is mostly ferns: the intervals are covered with fine grass only.

There has been much speculation as to the origin of these remarkable mounds. Some have supposed that they are Indian burial mounds, veritable cities of the dead. Others have thought that they are artificial mounds, upon which were built huts of Indian villages. Still others have thought that they were made by certain, perhaps unknown, species of fish, at a time when these prairies were still the bottoms of shallow inlets; that they were in fact large fish-nests. No one who has examined them can for a moment accept any of these views. They have been many of them opened, but nothing indicating artificial origin has ever been found.* Dr. Newberry has frankly acknowledged his inability to account for them.

When I first examined these mounds in 1871, they were to me also perfectly inexplicable. But upon subsequent reflection, and from what I heard of similar phenomena in portions of California, I long ago arrived at the conclusion that they are

* There have been many rumors of the opening of those mounds and the finding in them of human relics. Only very recently these rumors have been revived and extensively circulated in the daily prints. It was positively stated that the officers of the N. P. R. R. had opened several, and found undoubted evidences of human origin. I immediately wrote to the intelligent Superintendent, Mr. I. W. Sprague, asking for information. Only a few weeks ago I received answer from him, stating that the road does not run through Mound Prairie, that they had never found any relics of any kind, and as far as he could learn, no relics had ever been found in the mounds of Mound Prairie.

the *result of surface-erosion under peculiar conditions.* On conferring with Mr. Condon during my last visit, I found that he too had come to this conclusion. In my journey with him to the John Day Valley, I saw evidence which was perfectly convincing. The whole rolling country between the Dalles and the upper bridge of Des Chutes River, a distance of about thirty miles, is literally covered with these mounds. From every eminence the whole face of the country, as far as the eye could reach, presented a singular appearance, as if thickly broken out with a papular eruption. But the true key to their mode of formation is given here, as it was not at Mound Prairie, by the great variety of forms, sizes and degrees of regularity which they assume. They varied in *size* from scarcely detectable pimples to mounds five feet high, and forty in diameter at base, and in *form* from circular through elliptic and long-elliptic to ordinary hill-side erosion-furrows and ridges. In *regularity* of size and position, there was equal diversity; in some places being as complete as at Mound Prairie, i. e., they were all apparently of the same size, and touched each other at base; in other places they were of different sizes, and often separated by *wide pebble-covered spaces*, as if they were but the remnants of a general erosion of the surface-soil. Thus, on the one hand, portions of many square miles in extent were covered with mounds as large and as regular as any part of Mound Prairie, and *evidently produced by the same cause:* on the other hand, other portions were marked only by long hill-side furrows and ridges, *evidently produced by surface erosion*; and between these extremes every stage of gradation could be traced.

No one, I think, can ride over those thirty miles and observe closely, without being convinced that these mounds are wholly the result of surface-erosion acting under peculiar conditions. These conditions are a *treeless country* and a *drift-soil*, consisting of two layers, a finer and more movable one above and a coarser and less movable one below.* Surface-erosion cuts through the finer superficial layer into the pebble-layer beneath, leaving, however, portions of the superficial layer as mounds. The *size* of the mounds depends upon the *thickness* of the superficial layer; the *shape* of the mounds depends much upon the *slope* of the surface. The process once started, small shrubs and weeds take possession of the mounds as the *better soil*, and hold them by their roots, and thus increase their size by preventing or retarding erosion in these spots. The treelessness of the country in eastern Oregon has been produced gradually, since

* The necessary condition, I believe, is the greater movableness of the surface soil, as compared with the subsoil, whatever may be the cause of the greater movableness. In Oregon and Washington, the cause is a *pebble-subsoil;* in other places mentioned below, the cause may be different.

Post-Tertiary times, by the increasing dryness of the climate. We may imagine the mounds, therefore, as having been *held by the struggling remnants of a departing vegetation.* At Mound Prairie, however, the treelessness is probably produced by a contrary condition, viz: the extreme *wetness* of these lower level spots in winter. Here, therefore, the weeds and ferns hold and preserve the mounds, not only as the *better soil*, but also as the *drier spots.*

When once attention is turned to the subject, the same phenomenon in a less degree is observed in nearly all the treeless regions of California and Oregon, which have not yet been touched by the plough. On returning from Oregon, I observed it in the upper part of the Sacramento valley, where, however, the mounds are so small and inconspicuous as to escape observation unless attention has been previously awakened—only a light dappling of the surface of the country. Similar mounds, more conspicuous than the last mentioned, but far less so than these of Oregon and Washington, under the name of "hog wallow" are well known to exist over wide areas in middle and southern California. They dapple the whole surface of the eastern portion of the San Joaquin and Tulare Plains, and are found also in the country about Los Angeles. The smaller, sometimes scarcely noticeable mounds of California, graduate completely into the larger and more perfect ones of eastern Oregon, and these again into the still more perfect ones of Mound Prairie. If the mounds of Mound Prairie were an unique phenomenon, we might resort to exceptional modes of origin; but a phenomenon so wide spread must be attributed to the action of a wide-spread agent.

Oakland, Cal., Dec. 15th, 1873.

ART. XXX.—*On the Parallelism of Coal Seams;* by J. S. NEWBERRY.

IN the first volume of the Final Report of the Geological Survey of Ohio, Professor E. B. Andrews advances a theory in regard to the successive deposition of coal strata which, if permitted to go unquestioned, might seem to commit the other members of the geological corps to its approval, whereas, as a matter of fact, Prof. Andrews stands quite alone in its support. Very briefly, his theory is this: 1st, That coal-seams have accumulated in marshes along the sea shore, and therefore at or near the water-level; 2d, That the subsidences by which several coal seams were successively formed and buried were continental and general; and 3d, That the coal-beds—from their mode of formation—must necessarily be parallel to each other, and hence a discrepancy in the distances from a given coal-seam, taken as a base, to two or more outcrops of what might be considered the same seam, is a proof that the coal of these outcrops belongs to different seams. Prof. Andrews also says that he has never seen a coal seam dividing into two or more distinct seams, or two seams approaching each other.

While not questioning the accuracy of Prof. Andrews' report of his own observations, I am compelled to say that the facts observed by myself are not only discordant with his, but are such as seem to me to be incompatible with his theory. In the northern half of the Ohio coal-field, numerous instances of the approach and divergence of plainly continuous coal-seams might be cited. For example: On one tract of coal-land in Hubbard, Trumbull Co., the distance which separates the first from the second coal-seam varies from 44 to 100 feet; Coal No. 1 showing conspicuous waves or folds. while No. 2 is nearly horizontal (M. C. Read). At Fredericksburg, Wayne Co., the distance between the two limestone coals—Nos. 3 and 4—is only twenty feet, but on tracing these seams down the valley of the Killbuck, they are seen to gradually diverge, until at Millersburg they are eighty feet apart. At Fredericksburg again, the distance between Coals No. 4 and No. 6 is only about thirty feet; but in passing from this point eastward to Mineral Point, Tuscarawas Co., the interval increases to 104 feet, Coals No. 5 and 5*a* coming in between them. At Steubenville, the interval between Coals No. 6 and No. 8 varies from 502 to 564 feet; while going westward this interval diminishes to less than 400 feet along the western outcrop of the Pittsburg seam. On the banks of the Ohio, between Wheeling and Bellaire, the two coal seams next above the Pittsburg bed are seen, in a single exposure, to vary from 12 to 35 feet in the distance which separates them. On the banks of the Ohio, west of Wheeling, Coals No. 8 and No. 9 are about 150 feet apart; three coal seams, 8*a*, 8*b* and 8*c* being interposed between them. Thirty-five miles west of this locality, the distance between Coal 8 and Coal 9 is only 50 feet, with no intermediate seams (Stevenson). At Morgantown, West Virginia, on the east side of the Monongahela, the interval between the Pittsburg coal and the next succeeding one above (Redstone) is over 50 feet, consisting of limestone, 14 feet; shale, 3 to 10 feet; sandstone, 35 feet. On the west side of the river, three miles below, the distance between the Pittsburg and Redstone coals is less than 20 feet; the limestone remaining constant, the sandstone having entirely disappeared (Stevenson).

Any required number of cases like the preceding might be cited, but these, as it seems to me, will suffice to show that the intervals between our coal-seams are not constant. I learn from Profs. Dawson, White, Cox and Worthen, our most experienced coal geologists, that similar examples to those I have cited are not uncommon in the coal fields which they have so carefully studied.*

The fallacy of the theory of Prof. Andrews, as I think, consists in the supposition that the subsidence of our coal areas has been always continental or general, whereas, as it seems to me, the evidence is varied and abundant that this subsidence was often very local, and that in the long interval which elapsed between the formation of one coal-seam and the accumulation of carbonaceous matter above it, the strata were sometimes warped and folded in the most local and complicated way. It is also apparent that the deposition of the materials forming the strata of the Coal-measures was often quite irregular. This is conspicuously shown by the limited reach of the great sandstone wedges which sometimes locally separate or replace the more constant elements, the limestones, shales and coal-seams In some instances these beds of sandstone occupy narrow troughs of erosion; sometimes they form broad, lenticular sheets. It seems to me that we have some evidence that the local accumulation of these beds of sand produced local displacement of the mud on which they were deposited, just as they do at the mouth of the Mississippi, where the displacement results in the formation of "mud-lumps." But the theory of Prof. Andrews seems to me not simply untrue, but as calculated to do positive and practical harm, since teaching that a discrepancy of interval argues a want of identity in coal-seams, it tends to multiply their number and produce confusion in their classification.

ART. XXXI.—*Notes on some of the Fossils figured in the recently-issued Fifth volume of the Illinois State Geological Report;* by F. B. MEEK.

[Continued from page 193.]

Actinocrinites, Cyathocrinites, Codonites, etc.; Plate IX.—Most of the figures on this plate were drawn to illustrate the remarks on the structure and habits of the Paleozoic Crinoidea, commencing on page 323, and originally published by us, without figures, in the Proceedings of the Philadelphia Academy of Natural Sciences, some years back. As only a few references to these figures are given in that article as reprinted in

* See also the report of Prof. Ramsay, in the Report of the Coal Commissioners (England), vol. i, pp. 121 and 145.

the text, I have thought it desirable to indicate here more fully the particular figures on this plate, to which the student should refer while reading certain paragraphs of the remarks mentioned.

For instance, in connection with what is there said in regard to the structure of *Cyathocrinites* on pages 325 and 326, figures 13 and 14 of plate IX should be consulted. Figure 14 represents the upper side of *Cyathocrinites malvaceus*, as seen with the ventral tube and some other parts removed. In this condition, there would, on a hasty examination, seem to be two principal openings above, directly into the visceral cavity. That is, the posterior one (*an*), at the lower part of the figure, for the connection of the ventral tube, and a large central one (*h*): the former corresponding to the position of the anal opening, and the latter to that of the mouth, in *Comatula* and other existing Crinoidea. Previous to the discovery of these specimens, here for the first time illustrated, this was supposed to be the normal structure of *Cyathocrinites*, which has been described by the highest European authorities as having two openings through the vault. Our figure 13, however, of the same plate, representing the upper side of *C. Iowensis*, a closely allied species, clearly shows that, when the vault is *uninjured*, the central opening, as well as the ambulacral canals (*amc* of fig. 14), are covered over by small pieces, so that, during the life of the animal, the only communications to the central opening (seen at *h* in fig. 14) were through these covered ambulacral canals (*amc* of fig. 13), and under the small central vault-pieces covering the central opening itself.*

The discovery of this structure of the vault of *Cyathocrinites* is one of considerable interest, since it brings to light one of the most marked distinctions between this genus and *Poteriocrinites* (including as subgenera *Scaphiocrinus*, *Zeacrinus*, *Homocrinus*, &c., &c.), in which no such vault-structure exists, the whole ventral portion in these latter types being, on the contrary, enormously produced, in the form of a great cylindrical or ventricose upward extension, or so-called proboscis, composed of numerous small hexagonal pieces, with pores passing in through the sutures between them; the extension being often as wide as, or sometimes even wider than, the body below, and nearly or quite as long as the arms, as may be seen in *Zeacrinus acanthophorus*, plate XXIV, fig. 11*a*; as well as in several species figured in former volumes of the Illinois Reports. Although much has been written by authors respecting the distinctions between *Cyathocrinites* and *Poteriocrinites*, and some have even questioned the propriety of viewing them as distinct

* The form and size of these central vault-pieces may not be *exactly* as represented in fig. 13, as the sutures there are very obscure in the specimen, and they are too strongly and decidedly defined in the engraving.

genera, this very strongly marked and striking difference between them seems to have been entirely overlooked as a distinguishing feature.*

This peculiarity of the vault in *Cyathocrinites* also (along with other differences) appears to distinguish this genus from those great ponderous species, often referred to *Cyathocrinites*, for which Mr. Wachsmuth has proposed the name *Barycrinus* (see fig. 2, pl. XII; figs. 1, 2 and 3, pl. XIII; and fig. 8, pl. XX), because we have the strongest possible negative evidence for believing that in the latter no solid calcareous vault-pieces of any kind ever existed. It likewise has an important bearing on the much mooted question, to be mentioned farther on, in regard to the position of the mouth, and the manner in which the food is conveyed to the same, in the Paleozoic crinoids.

While reading the remarks on pages 327 to 329, on the internal convoluted organ so often seen in the *Actinocrinitidæ*, the student should turn to figures 6, 7 and 12, of plate IX, as well as to fig. 3 of plate VII. Since these remarks were published, however, farther examinations of other specimens have led me to think it quite probable (contrary to the statement on page 328, in regard to its structure in *Batocrinus Verneuilianus*) that this organ was, in *all* cases, composed of a delicate net-work of calcareous bars, as shown much magnified in fig. 6*b* of plate IX; and that the apparently more dense structure illustrated by figs. 8*b*, 12*c* and 12*d*, of the same plate, was produced by the deposition of crystalline inorganic matter on the delicate bars of the net-work.

Figures 7*a*, *b* and *c* of plate IX were also drawn to illustrate the remarks commencing on page 329, on the existence of ambulacral canals composed of minute calcareous pieces, and converging inward from the arm-openings to the top of the large internal convoluted organ, in the *Actinocrinitidæ*. Fig. 10 of the same plate, it will also be seen, shows deep furrows in the under side of the vault of *Actinocrinites? ornatus*, for the reception of these internal ambulacral canals, as mentioned on page 332; and fig. 9 illustrates casts of these furrows as exhibited in a cast of the interior of the vault of apparently the same species. Upon examining these figures, it will be observed that the deep furrows in the under side of the vault do not converge to the single opening (*an*) in the vault, but, as in the ambulacral furrows of *Cyathocrinites* (figs. 13 and 14), to a

* I certainly must believe that Goldfuss was much nearer right in referring his *Cyathocrinites geometricus* to that genus, than those who have placed it in the genus *Poteriocrinites*; though it does agree more nearly with the latter in the much less important character of its anal series of pieces. Its nearly flat vault, however, scarcely, if at all, rising above the arm-bases, without any traces of the great ventral extension, composed of numerous small hexagonal pieces with pores between, as we see in *Poteriocrinites*, seems to me to separate it from the latter group entirely.

central point in advance of it; precisely as the ambulacra in *Comatula* converge to the mouth in front of the anal opening, excepting that in the latter neither the mouth nor the ambulacral canals are covered by solid calcareous vault-pieces.

As widely different as the *Blastoidea* would, at a first glance, seem to be from the typical crinoids, in the structure and arrangements of the parts mentioned above, an attentive comparison will show that, fundamentally, there is less difference between these types than might be supposed. For instance, if we examine a *Pentremites* or a *Granatocrinus* (see fig 4*b*, pl. IX), as the specimens are most generally found, we observe that they show two principal openings above; that is, a central one, to which the ambulacra converge, and another behind this, just as in the incomplete *Cyathocrinites* represented by figure 14 of same plate. Specimens in a better state of preservation, however, such as those represented by our figures 2*a* and 2*b*, of *Granatocrinus Norwoodi*, and fig. 5 of *Codonites stelliformis*, show that, when the parts of the summit are intact, the central opening, and perhaps a part of each ambulacral furrow, are covered over by minute fixed pieces, as in the more complete *Cyathocrinites*, fig. 13; the ambulacral canals in both cases passing under the vault-pieces, inward to the central opening.

In the *Blastoidea*, there are, however, other small lateral openings in the summit, as seen at *ir*, *ir*, in figures 2*a* and 2*b*, and at *s*, *s*, in figure 5 of plate IX. These are the so-called ovarian apertures of many authors, and have been called hydrospires by Mr. Billings, who, with several others, regards them and a curious series of internal parts with which they connect, as the water-breathing organs of the animal. Although some recent investigations of the anatomy of existing crinoids, by Metschenhoff,* would seem to cast doubts on the correctness of this conclusion, it is certainly more probable than that these were ovarian openings; which would apparently be against all analogy from what is known of the reproductive system of the existing crinoids, in which the ambulacral and reproductive organs are directly connected.

Whatever office these openings may have performed in the animal economy of these types, however, we have some reasons for believing that, in the *Actinocrinitidæ* at least, there were analogous apertures, which were also called ovarian pores by Prof. McChesney, in describing certain species of this group. These are small pore-like openings, very regularly disposed with relation to the interradial and other spaces around at the connection of the body and vault; one being placed near one side of the base of certain arms, at regular intervals, all around.

* **Bull. Acad. St. Petersburg, XV, p. 508.**

These little openings have often attracted my attention; and, although once inclined to attach more importance to them, at the time our remarks on the structure of the Paleozoic crinoids were written, I could not feel quite satisfied that they might not have been for the attachment of the inner pinnule of that side of each arm-base where they occur, and concluded to wait until their true nature could be more clearly determined, before calling attention to them. Mr. Wachsmuth subsequently assured me, however, that, after examining a great number of specimens in every condition of preservation, he has never seen any evidence of the connection of pinnules with these openings; and consequently he suggested that they may correspond to the so-called ovarian apertures of the *Blastoidea*;* a conclusion that seems to derive support from the following additional fact. That is, that on tracing these openings through the wall of the body, they do not, so far as my observations have gone, appear to take the direction that would indicate any immediate connection with the ambulacra, but, on the contrary, turn more downward, increasing in size as they pass in, thus appearing as if they might have connected with some internal cavity, or system of cavities, between the outer wall and the visceral sack. In fact, we also observe, in some instances, evidences that some such cavities were partitioned off, as it were, by an incomplete inner calcareous wall, secreted (perhaps only in old individuals) by the perivisceral membrane, as represented by our figure 11 of plate IX.

The unmistakable evidence presented by some of the specimens figured on plate IX, that the ambulacral canals continued on converging inward *under* the vault, from the arm-openings to a central point at the top of a large convoluted organ believed to be the digestive sack (as seen in fig. 7*a*), led us, as suggested on page 334 of the reproduced remarks, to think that the positions of the mouth and anus, with relation to the ambulacra and other parts, in these older types, were essentially the same as in the recent crinoids. That is, we believe that, in the Paleozoic types, as in the recent *Comatula*, the mouth was situated centrally at the radial point of the ambulacra, and that the microscopic organisms, on which these animals doubtless subsisted, were converged by the action of cilia along the ambulacral canals, to an internal mouth or esophageal opening, situated under the center of the vault: while the single opening of the vault, always located at some point behind the center of radiation, whether simple or passing

* I think Mr. Billings has alluded to these openings in *Actinocrinites*, in some of his papers (which I have not at hand for reference at this time), after receiving specimens from Mr. Wachsmuth, with the same suggestions from the latter gentleman in regard to their nature.

through a more or less produced tube, we regard as the anal aperture, as in the existing crinoids; and not the mouth, or both mouth and anus, as believed by some.* The only difference, therefore, as we understand the facts, is that, in the recent types, the ambulacral canals and mouth are directly exposed externally, the former merely passing to the latter across the upper surface of a membranaceous ventral integument; while, in the ancient crinoids, the whole ventral surface (excepting the anal opening), as well as the ambulacral canals and mouth, was very generally, if not always, covered over by a vault of fixed, solid, calcareous pieces.

That some of the most distinguished naturalists of Europe, including Professor Wyville Thomson, of Belfast, the lamented Prof. Michael Sars, of Christiania, and others, to whom we several years back sent photographs of plates IX and XVI, substantially concurred with us in the foregoing interpretation of the facts presented by the specimens illustrated on the same, we have been assured, both by private letters from these gentlemen, and in some instances by their publications.†

It is proper, however, to state here, that Mr. Billings, the very able paleontologist of the Canadian Geological Survey, who is one of the highest authorities on the Paleozoic crinoids, dissents from these views, and maintains, with much ability, that the single opening in the vault of these old types performed both oral and anal functions; or, in other words, that the mouth, unlike that of the existing crinoids, was, in the former, removed from the center of radiation, and consequently from all direct connection with the ambulacral system.

Codonites stelliformis, figures 5 and 5*a*, *b*.—In connection with the foot-note on page 464, in regard to the parts described by

* That the single opening seen in the vault of these ancient crinoids could not have performed both oral and anal functions, at least in *Platycrinites*, seems almost demonstrated, by the fact that we often find (as mentioned on pages 334 to 339 inclusive, and illustrated by figures 6*a*, *b*, *c*, of plate XVI) specimens with the shell a *Platyceras* growing firmly over this opening, under circumstances clearly showing that it grew there *during the life of the crinoid*. In these cases, we can readily understand how the excrementitious droppings of the crinoid may have passed out under the foot of the mollusk; but it would be exceedingly difficult to explain how food could have passed in under such circumstances.

† In justice to Dr. L. Shultze, of Bonn, I avail myself of this opportunity to call attention to the fact, that he had, in his beautiful Monograph of the Echinodermata of the Eifel limestone, published in 1866, expressed very similar views in regard to the internal position of the mouth, and the mode of alimentation, in the Paleozoic crinoids; though the specimens at his command for study were far from being as clearly satisfactory on these points as those figured by us are believed to be.

At the time we first published our remarks on this subject, in 1868, we had not seen his work, and had no knowledge of the fact that he had ever expressed similar views, or we should certainly have mentioned it. I regret that I have not his Monograph at hand now, so that I could quote his words, or refer more precisely to the pages on which they occur.

Mr. Lyon as the true basal pieces, in the *Blastoidea*, but which we have viewed as belonging more properly to the column, fig. 5*a*, referred to above, should be consulted. In this side-view of a young *C. stelliformis*, it will be seen that this part is composed of anchylosed upper disc-pieces of the column, divided longitudinally by three sutures, coincident with those between what we regard as the true basals above. The engraving makes the divisions between the discs too distinct, but they are well enough defined in the specimen to show their true nature.

Pholidocidaris irregularis M. and W.; plate XV, figs. 9*a*, *b* and 4*c*, *d*, *e*.*—This very extraordinary echinoid, as yet only known from flattened fragments, was at first supposed by us to be related to *Lepidocentrus* of Müller, to which we referred it provisionally, in the Proceedings of the Philadelphia Academy, in 1869. At the same time, however, we remarked that a comparison of the ambulacra might show our fossil to be entirely distinct, and suggested that in that case it might be called *Pholidocidaris*. At that time we knew nothing of the ambulacra of *Lepidocentrus*, which was founded by Müller on detached interambulacral pieces, some of which resembled certain corresponding parts of our type. On seeing Dr. Shultze's figure, however, of Müller's genus, published in his Monograph of the Eifel *Echinodermata*, we were at once satisfied that our echinoid belongs to an entirely distinct genus, the ambulacra of *Lepidocentrus* being (as shown in Dr. Shultze's figure) each composed of only two ranges of widely different pieces, as in *Palæechinus*. Consequently, in republishing the description of our type, we have adopted the name *Pholidocidaris* for it.

In this connection, it may be worthy of note, that it is evident from Dr. Shultze's figures that *Lepidocentrus* Müller, 1856, and *Lepidechinus* Hall, 1861, are in all respects congeneric; and, as Müller's name has priority of date, it will have to be retained for the group; thus making *Lepidechinus* a synonym. Consequently, the names of the American species, *Lepidechinus imbricatus* Hall and *Lepidechinus rarispinus* Hall, will have to be written *Lepidocentrus imbricatus* and *Lepidocentrus rarispinus*.

Pentremites (*Troostocrinus ?*) *Woodmani* M. and W.; plate XVI, figs. 4*a*, *b*, *c*, *d*.—In describing this fine species, we inadvertently omitted to mention that the central pit seen in the base was evidently left by the accidental removal of the parts we have called the supplementary basal pieces, in other types of the *Blastoidea*. (See the foot-note on page 464, already cited in these notes, in connection with *Codonites stelliformis*, as illustrated by fig. 5*a*, pl. IX.)

* Figures 4*c*, *d*, *e* should have been 9*c*, *d*, *e*, in the explanations of the plate.

It is highly probable that the group including this species should be separated as a distinct genus from the typical *Pentremites*, such as *P. Godoni*, *P. pyriformis*, &c. Our deceased friend, the late Dr. B. F. Shumard, of St. Louis, proposed the name *Troostocrinus* for a group to which he referred at least one species (*Pentremites obliquus* Roemer) evidently closely allied to our type. Roemer's species was founded on a single radial (fork) piece, but its lower end shows an oblique flattening or excavation, similar to (though more shallow than) the deep concavities seen in the corresponding parts of our species.

Whether such forms should be included in the same group with those very narrow, elongated, fusiform species, such as *Pentremites Rheinwardtii* of Roemer, with the base and lower parts of the body much attenuated and merely a little flattened on three sides, may admit of some doubts; though Dr. Shumard included the latter in his genus *Troostocrinus*. Another reason why we hesitate in retaining his name for the group including our type, is, that he mentions *Pentremites laterniformis* of Owen and Shumard in such connection with his genus that, according to the rule followed by many eminent naturalists, that species *only* could be regarded as the type of the same. Unfortunately, however, it is now rendered almost morally certain, by specimens in Prof. Worthen's collection, that *P. laterniformis* was founded on the internal cast of a true typical *Pentremites*. Consequently, if we adopt that as the type of *Troostocrinus*, we would have no other alternative than to regard that name as merely a synonym of *Pentremites* Say.

Although far from being inclined to "strain a point," in order to set aside a published name, and really desiring to retain that proposed by Dr. Shumard, for the group to which our species belongs, if it can be consistently done, we have proposed, in case serious objections should be raised against such an arrangement, to call our type *Tricœliocrinus*.

(To be continued.)

ART. XXXII.—*Laboratory Notes*; by M. CAREY LEA, Philadelphia.

I. *Solubility of certain Silver Salts in solutions containing Sodic Citrate.*

SOME statements on this subject appear in our text-books which must either be regarded as entirely erroneous, or else must be understood in a very much more limited sense than they are expressed. In Storer's most useful Dictionary of Solubilities I find it stated relative to argentic citrate, that "it is not precipitated from solutions containing citrate of soda." Of argentic tartrate and monochromate, the same statement is made in the same words. Of argentic tartrate it is said still more strongly: "It cannot be precipitated from solutions which contain citrate of soda." These citations * are all on the authority of Mr. John Spiller.

In the course of some investigations connected with salts of silver, I obtained results so contrary to these statements that I was led to examine specially the influence of sodic citrate on the precipitation of these silver salts, which resulted as follows:

1. A strong solution of crystallized terbasic sodic citrate was made; a single drop of solution of argentic nitrate added to this caused a precipitate which disappeared on warming; the addition, however, of a very little more caused a permanent precipitate which did not redissolve by heat. When to the solution of sodic citrate was added citric acid, the silver reaction was the same.

2. *Argentic Oxalate.*—When oxalic acid is dissolved in a solution of sodic citrate, even a single drop of silver solution produces a permanent precipitate which does not disappear on warming or even boiling.

3. *Argentic Tartrate.*—A considerable quantity of silver solution can be added to one of tartaric acid before a precipitate falls. It naturally follows therefore that when to a solution containing tartaric acid and sodic citrate we add a silver solution, no precipitate is at first formed: when a sufficient quantity is added an abundant permanent precipitate is formed.

4. *Argentic Chromate.*—When a little solution of neutral potassic chromate is added to one of sodic citrate, the first drop of silver solution produces a brown precipitate which is permanent, and does not disappear even by boiling.

5. If to a solution of sodic citrate be added silver salt as long as the precipitate dissolves by warming, this solution shows the following reactions. *Chromate:* A portion of the solution added to one of neutral potassic chromate produces a precipitate which does not redissolve. Even a drop of the solution produces this effect, unless the quantity of the solution to which it is added be very large. *Oxalate:* The solution dropped into aqueous oxalic acid gives a precipitate which at first redissolves, but as more is added it becomes permanent and does not redissolve even by boiling. *Tartrate:* Similar reactions.

6. Finally, to a quarter of an ounce of strong solution of sodic citrate, as much silver was added as it would take up. *Into this* a fraction of a drop of solution of neutral potassic

* They are not to be understood as being adopted by the author of the "Dictionary," who has simply collected all published statements.

chromate was added. A red precipitate that did not redissolve was produced.

7. To a similar strong solution of sodic citrate, citric acid was added, and the experiment repeated under these conditions. The first drop of chromic solution did not produce a precipitate; a little more produced a precipitate not redissolving by heat.

8. To a strong solution of sodic citrate with silver, as in (6), oxalic acid was added. The first drop troubled the liquid; a little more produced a heavy precipitate.

In the first four of these trials, silver solution was added to one of sodic citrate, containing the oxalic, tartaric, &c., acids. In the three in paragraph (5), the solution of sodic citrate was charged with as much silver as it would take up, and this was added by degrees to the solution of chromate, oxalic acid, &c.; in (6), (7) and (8), this was reversed and the precipitating solution was added by degrees to a very large excess of the solution of silver in sodic citrate. Thus the trial was varied in every possible way and in every case precipitates were obtained, often with extremely small and always with small quantities of the precipitant.

II. *Molecular conditions of certain Iodides.*

If mercuric iodide be dissolved in a quantity of boiling water and the solution be poured out, one-half into a cold porcelain basin and the other into a beaker of cold water, the iodide quickly separates in both cases, but in the former with a bright scarlet color, in the latter with a pale yellow, and only after some hours' standing recovers its normal scarlet.

When nickel iodide (obtained by dissolving nickel carbonate in aqueous hydriodic acid) is evaporated in a basin, and the sides of the basin above the liquid become hotter than 212°, the adhering nickel iodide turns black. Paper dipped in the solution and heated turns intensely black. Nickel chloride shows the same result, but at a higher temperature. Potassic bromide dissolved with the nickel chloride lowers the temperature at which the blackness comes.

This blackening is permanent and the paper itself is acted upon. The change takes place far below the temperature at which paper chars.

III. *Criticisms on some results of M. S. Bottone.*

In the December number of this Journal appears an abstract of some experiments of M. S. Bottone, directed to prove that the hardness of any element is as the specific gravity divided by the atomic weight. The hardness of each element, calculated according to this postulate, is placed in a column parallel with the hardnesses as deduced from the time required by a steel plunger, revolving at a uniform velocity, to penetrate to a given depth in the substance under examination.

The results obtained in this way by Mr. Bottone, though agreeing quite well with the calculated figures, seem to be at variance with facts, as appears by a simple comparison of one with another. Thus gold, a very soft metal, is made more than two-thirds as hard as iron, ·0979 to ·1375. Zinc approaches still nearer to iron ·1077 to ·1375. Lead is made to be but little harder than sodium, ·0570 to ·0400. Sodium is made nearly one-third as hard as iron, ·0400 to ·1375.

It is still worse when we come to the diamond. Bottone finds the diamond to be but little more than twice as hard as iron, less than six times as hard as lead, less than eight times as hard as sodium, a metal as soft as wax. It does not seem possible to accept the statement that a revolving steel plunger will penetrate a quarter of an inch into a diamond, in less time than, all other things being equal, it will penetrate an inch and a half into lead.

Art. XXXIII.—*The Auriferous Gravel Deposit of Gold Bluffs*; by A. W. Chase, Assistant U. S. Coast Survey.

(Read before the California Academy of Sciences, Jan. 5th, 1874.)

I propose to ask your attention, for a few moments, to a brief description of the somewhat celebrated deposit of auriferous gravel on the coast line of Klamath County, California, called the Gold Bluffs, and the method of gathering the beach sands and extracting the gold therefrom, now practised at the two mining claims which are worked there.

Coming from the north, after leaving the Klamath River, the coast line is extremely broken and rocky, the rock being principally metamorphic sandstone, with an occasional cliff of chert or jasper in regular layers or strata. At a point about four miles south of the river, banks and deposits of gravel appear, although the commencement of the bluffs proper is at the mouth of a creek called the Ossegan and seven miles from the Klamath. Then, for nine miles, there is an almost unbroken line of cliffs, varying from 100 to 500 feet in height. Many of the bluffs are absolutely vertical and in some instances overhanging. At low water there is a narrow beach, but when the tide is full the sea washes directly against the base of the cliffs: the beach is then impassable.

The mountains back from the coast, of which the bluffs form the sea-escarpment, are all one immense mass of gravel, of varying size and distinctly marked layers or stratifications. This gravel can be traced across the country, northeastwardly, to a point on the Klamath River about thirty miles distant, where the same form of deposit makes its first appearance as you ascend the river.

As the bluffs are similar or nearly so in stratification, I have sketched a section of one, from under which the specimens of black sand or magnetic iron ore, which on examination you will find rich in fine gold, were taken. (Specimens presented with this paper.) The height of this cliff from low-water mark is about 227 feet, and the sketch represents a vertical section The thickness of the different strata, I would remark, are by estimation, as I had no available means of determining them with exactitude.

Commencing from the top, we have first a section of ten feet of loam; then twenty feet of yellow clay; then forty feet of coarse yellow gravel; then a stratum of sandstone of brownish color, ten feet; next forty feet of red and yellow gravel; then five feet of a blue-colored sandstone. Projecting from this layer are numerous stumps and other portions of trees, partially transformed into lignite. A specimen of this lignite is presented with this paper. Then we have fifty-five feet of a very coarse red and yellow gravel, and immediately beneath it five feet of very fine blue-colored gravel; then fifteen feet of indurated sand; then ten feet of gravel, stained deep red, probably from the presence of oxide of iron. Beneath this is another stratum of sandstone, five feet, blue in color, with pieces of the lignite before referred to projecting from it; then five feet more of blue sandstone without any lignite; then seven feet of gravelly beach to low water mark.

This cliff which I have described is at the lower end of the bluffs, and near the mining works. The strata all dip to the *north* at an angle of about 15°; while those on the north end, although much broken, seem to dip toward the south.

A specimen of the stratum No. 10 from the top is presented. You will see by examination that the presence of mica and fine gold can be detected with the microscope. The specimen obtained was a concretion cemented together on a large boulder by the oxide of iron. It is my belief that from this stratum the largest amount of fine gold is obtained.

Before attempting to form any theory as to the origin of this vast deposit of auriferous gravel, I will give a brief description of the history of the gold working of the beach, and the present mode of operation. In 1850, when this portion of the coast line was still in undisturbed possession of the Indian tribes, a party of adventurers travelled from Trinidad up, seeking for the mouth of the Trinity River, which, instead of being in reality an affluent of the Klamath, was supposed to have a separate mouth. One of the party was J. Johnson, now a resident of Crescent City. At a favorable spot on the beach they saw glittering particles in the sand, and on examination found them to be gold. Gathering some of this gold, they went back, greatly excited, to Trinidad, to procure provision.

On their return, however, they found nothing but a bed of gravel, a change in the direction of the surf having carried away or covered up the glittering treasure. It may be remarked here that when the direction of the wind is such that the surf breaks square on the beach, it rolls up masses of coarse gravel, and no black sand is visible; but that, when it cuts the beach at an angle, the gravel is washed into heaps in certain spots, and in others black sand is deposited, more or less rich in gold.

After this discovery ensued the so-called "Gold Bluff excitement." The first mining claim was taken up the same year by Bertrand and Nordhamer. The beach sands were worked with sluices, the gold being caught in riffles sawed in a plank, loaded with quicksilver. From that time to the present these beaches have been steadily worked; the highest amount taken out in any one year, up to the present, being said to be $25,000, for the lower claim. The proprietors have, however, labored under the disadvantage of a scanty supply of water, not being able to keep their sluices running more than one-third of the time. I will now give a description of the present method of working, as witnessed by myself.

I rode up the beach with the superintendent of the lower claim, just as the tide was turning to go out. His practised eye noted every indication of the presence of black sand. Alighting at a spot at the base of the cliff, a section of which I have just shown you, he scraped away the loose gravel and taking up a shovel-full of the sand lying beneath, panned it out in a little pool of water left by the receding tide. A rim or circle of fine gold around the spot of sand indicated the richness of the layer. A messenger dispatched to the works soon brought down the mule train. There are some forty animals employed, although in the present instance but sixteen of them were used. Each mule carried a couple of sacks of coarse canvas attached to the pack saddle. Each sack will contain about 150 lbs. of sand and gravel; the mule packing therefore 300 lbs.; and the train of sixteen, 4800 lbs., or nearly two tons and one-half at a trip.

The top gravel being stripped off, the underlying sand was gathered into little piles. While the men were thus engaged the superintendent invited my attention to the appearance of the bed-rock or hard strata underneath the sand after it was stripped. It glittered with fine particles of gold, and I could then well believe the stories of the first discoverers.

So exceedingly fine, however, is the character of this gold, that it requires a much larger quantity of these particles to reach the value of a cent than one not familiar with the subject would suppose. Specimens of the sand as taken from the beach are presented with this paper. On microscopic examination, besides the gold and magnetic iron ore, the sand will be seen to contain minute and brilliant red particles, which I believe to be spinel in some of its forms. Other translucent particles will be seen.

Prof. Silliman, in notes on the Mineralogy of California, Utah and Nevada, mentions a variety of minerals as composing the black sands of Butte County. It is probable that all or nearly all of these will be found in the sands from Gold Bluff. As there are large deposits of chromic iron in the county adjoining, it is probable that chromite forms a portion of the black sand.

Prof. Silliman mentions syenite as the matrix from which most of the minerals he enumerates came. I present a small pebble of syenite from Gold Bluffs. It is a common factor in the gravel masses.

To return now to the description of the process of gathering the sand. After it had been, as mentioned before, shovelled up into little piles, the canvas sacks were taken from the mules and filled. With a word from the driver each mule gravely walked up between his sacks. On their being placed on his back he would start off on a trot, for the works. I watched the movements of these animals with a great deal of interest: they had to pass several points where the sea was breaking pretty well up on the bluff. When they saw a heavy breaker coming in they would face the cliff like veterans, and, with firmly braced feet and drooping ears, allow the water to dash over them; when the swell receded, off they would start again. During the time I was present these mules made three trips, carrying up on the whole some six or seven tons: this was on a single tide.

On arrival at the works the sand is deposited in an enclosure called the "sand corral." A large lagoon near by supplies the necessary fresh water for separation. A small stationary engine and force-pump is in use. The washing is done in machines called Long Toms, the gold being caught on copper plates which are charged with quicksilver. Formerly it is believed that a large percentage of the gold, ground down as it was by the wearing action of the surf to a powder, was lost. Now the plates are first coated with a layer of silver before the mercury is applied. Sodium is also used to free the quicksilver from impurities. A ton of the tailings, analyzed in San Francisco after this improvement had been effected, did not afford a trace of gold. The copper-plates in use, especially in the old process, become quite valuable after continuous service, the copper being replaced by an almost pure amalgam of gold and quicksilver.

During the week that I was in the vicinity of the works, they cleaned up a six or seven days' run and retorted $1600 from the washing of the two machines, each employing two men. The succeeding week they cleaned up $1700. Of course this yield comprised the gold from a portion at least of the rich deposit I have described.

Since the experience of the successive proprietors of this extraordinary gold mine go to prove that immediately after a heavy cave or slide of the banks, the beaches are richer and the gold coarser, it seems strange that up to the present time, no artificial means have been resorted to, in the way of blasting down the cliffs or undermining them by hydraulic power, to increase the yield of gold. The sea working night and day is the great natural separator, and man has but to gather the results of its tireless work.

Many ideas have been advanced as to the possibility of gold in quantities and coarser in character being found beyond the lines of surf, predicated on the fact that *it* in conjunction with black sand has been said to have been brought up from the bottom by the leads of sailing vessels, and I believe an expedition was fitted out to obtain this sand by means of a diving-bell or some such apparatus, which did not result favorably.

Two or three facts can be taken in conjunction here to form an idea on this subject. The first is that the gold evidently comes from the bluffs. This no one can doubt after once viewing them. The second, that after "caves" the gold obtained is much coarser in character. The third, that it is only after a continued succession of swells that cut the beach at an angle, that the rich sands are found. When the surf breaks square on, let the storm be ever so heavy, it simply loads the beaches with gravel. The fourth, that no one witnessing the power of the surf breaking as it does with no rocky headlands, points or rocks to deaden it, can doubt that it must have an immense grinding force. From these facts I am inclined to believe that the gold follows the first two or three lines of breakers and will never be found in paying quantities beyond. As you will see by examination of the specimens, this gold is so light in character that when dry it will float on the surface of water.

In endeavoring to account for the presence of these remarkable gravel banks, unique I believe on the Pacific coast, one is inclined to think that they were the deposits of a great river of the past, occupying the bed of the present Klamath, but having its debouchure here. The fact that the gravel is flattened and oblong in shape as a rule, the presence of lignite in different strata and of river sand in others, would go to confirm this theory, although the broken and disrupted character of the mountains back is an evidence of after disturbance.

I present a fossil vertebra, obtained from the bank mentioned, which may throw some light on the subject. Whatever may have been the origin of these deposits, and I do not profess from lack of experience to form a definite opinion, it is certain that they offer an inviting field for the geologist and will some day demand careful study.

After the completion of this paper, I received a letter from Prof. J. D. Dana, to whom I had sent specimens of the sands of Gold Bluff, from which I extract the following remarks:

"The red grains in the sand are garnet. It is altogether probable that the deposit dates *partly* from the close of the Glacial era; that is, the time of melting of the ice in the early part of the Champlain period, when floods and gravel-deposition were the order of the day, and *partly* from the later part of the Champlain period, when the floods were but partially abated, yet the depositions were more quiet."

Art. XXXIV.—*Notices of Recent Earthquakes.*—No. 4; by Prof. C. G. Rockwood, Jr., Rutgers College.

May 15, 1873.—Several shocks of earthquake were felt at Valparaiso, Chile. They commenced at 12.32 P. M. and lasted forty-two seconds. The motion was vertical. Several persons were hurt and killed; the Church of the Apostles was injured and the Merced was left in a dangerous state. Many other public and private buildings were more or less damaged. Severe shocks were also felt at Quillota and Santiago and slight shocks at various places as far south as Concepcion.

June 29, 1873.—Severe shocks were felt at 5 A. M. in Venice and Verona, Italy, and the country north of those cities. The shocks were most violent about Belluno, fifty miles north of Venice. Here several persons were killed and a church tower was thrown down. In all, twenty-four deaths are reported, and a large amount of property was destroyed. Mr. W. Stark writes from Venice to the London Times, as follows: "There were fourteen movements in all, seven forward and seven backward, and each movement occupied a second, as regular and even in its beat as the pendulum of a clock, and with the last backward movement there was a sudden and instantaneous stop in its center: the earth was firm once more."

July 3, and 6, 1873.—Fresh shocks were reported at Belluno and vicinity.

July 6, 1873.—A distinct shock was felt throughout western New York and adjacent portions of Pennsylvania and Canada. At Buffalo and at East Otto, N. Y., light shocks were felt about 4 A. M. and a few minutes before 7 A. M.; but the most severe shock, and the one most widely felt, occurred about 9.30 A. M. This was felt as far south as Wheeling, West Va.; at Erie, Meadville and Titusville, Pa.; at numerous points in Chautauque, Cattaraugus and Erie Counties, N. Y.; at Buffalo and Lockport, N. Y., and at Georgetown, St. Catharines, Hamilton and London, Canada. The time reported at the several stations varies from "about 9.12" A. M., at Hamilton, to "22 minutes before 10," by one observer at Buffalo. The majority of the reports say about 9.30. There is even greater diversity of opinion as to the direction of the vibration. A writer in the Buffalo Courier says: "It commenced with a shock of considerable violence, a tremor succeeding this which maintained a degree of uniformity for some seconds, and finally it died away gradually into an almost imperceptible tremulousness. There are different opinions as to the direction of the wave, and the time it lasted is variously estimated at from twelve seconds to a minute. Our notion is that it continued some twenty seconds." At Lockport, Fredonia, Randolph and Cattaraugus, N. Y., and at Erie, Pa., a rumbling noise was heard. At East Otto, N. Y., another shock was felt about 11 A. M.

July 8, 1873.—A severe earthquake was felt at Valparaiso, Chile, at 2.22 A. M. Considerable damage was done to many houses and churches and some few lives were lost by falling walls. In Santiago the shocks were severe, but no great damage was done.

—— —— A slight shock at Halifax, Nova Scotia, on the same forenoon.

July 12, 1873.—Slight shocks in Italy, at Rome. Frosinone, Alatri and Paola.

—— —— On the same day a severe earthquake was felt throughout Nicaragua, consequent upon the eruption of Momotamba volcano.

July 15, 1873.—A slight shock at Napa, Cal.

July 16, 1873.—A slight shock in the morning at Worcester, Mass., lasting about five seconds, with very distinct rumbling.

Aug. 2, 1873.—A slight shock about 10 P. M. in Santa Fé, New Mexico.

Aug. 17, 1873.—A shock about 9 A. M. in Sharon, Pa., lasting ten seconds.

Aug. 29, 1873.—A heavy shock of earthquake was felt at mission, San Jose, California, at 4 P. M., but resulting in no damage. The shock was quite heavy at Redwood City and other towns in Santa Clara Valley, but was very slight in San Francisco.

Sept. 17, 1873.—A sharp shock at 9.30 P. M. at Lucca, Italy.

Sept. 26, 1873.—The weather observer at Kingston, Jamaica, reports that an earthquake was felt there at 1.45 A. M.

Sept. 30, 1873.—A severe shock, lasting about 40 seconds, was felt at 6.50 A. M. at the Desert on the Gatineau in Canada. The same shock was felt at St. Hyacinthe and by a few persons in Montreal.

Oct. 3, 1873.—A slight shock at 7.45 A. M. at Burkeville, Va., and vicinity, with a low rumbling noise.

Oct. 5, 1873.—A shock at 2.30 A. M. at Lake Village, N. H.

Oct. 10, 1873.—A slight shock at 4.45 A. M. in the city of San Salvador, Central America.

Oct. 12, 1873.—A shock at 1.15 A. M. at San Diego, Cal.

Oct. 13, 1873.—A shock occurred on the Isthmus of Panama. The following is condensed from the Panama Star and Herald: "In the city, the shock was strongly felt about 6.05 P. M., the night being dark and sky overcast. It lasted four or five seconds, and was felt on board of the ships in the harbor, along the line of the railroad and at Aspinwall. A correspondent writing from San Pablo, one of the stations, says: 'We had two pretty severe shocks with an interval of but a second or two between them. The second shock was most severe and accompanied by a rumbling sound.' In Aspinwall, the shock was felt about ten minutes later and more severely than in Panama. Most people agree that the oscillations proceeded from southeast to northwest."

Oct. 19, 1873.—A slight shock was felt about 2 P. M. at Seattle, W. T., "and at 4 o'clock clouds of smoke were seen pouring from the highest peak of Mt. Ranier."

Nov. 1, 1873.—A cable dispatch announces that the volcano of Etna is in a state of violent eruption. It states that the outbreak is accompanied by earthquakes, and that portions of the crater had fallen in, destroying mines of sulphur, which were valued at £300,000.

Nov. 4, 1873.—Mr. T. L. Clarke kindly sends the following report of an earthquake at his home, Makawao, Maui, Hawaiian Islands. The location is 2170 feet above the sea, on the north slope of the mountain of Haleakala.

"Between 10 and 11 P. M four distinct shocks of the 'cannon ball' type, preceded by faint rumbling. Apparent direction from south to north; duration, four seconds. This shock was felt, about the same time, on the island of Oahu, about 100 miles distant. By 'cannon ball' is meant the jarring feeling without oscillation."

Nov. 4, 1873.—Two distinct shocks at Burlington, Vermont, between 11.30 and midnight.

Nov. 6, 1873.—Three quite severe shocks at Austin, Nevada.

Nov. 13, 1873.—A slight shock at Bangor, Me., in the night.

Nov. 22, 1873.—A shock was felt along the Pacific coast and vicinity, from Portland, Oregon, to San Francisco. At these extremes the shock was scarcely perceptible. It was most violent at Crescent City, California, and Port Orford, Oregon (places situated on the coast near the boundary between California and Oregon.) At the former place nearly every brick building suffered more or less damage from cracked walls and falling chimneys. It was quite heavy at various points in the Coast Range of mountains, the severity diminishing north and south from the neighborhood of the State boundary line. The duration is stated at 20 to 30 seconds, and the time a few minutes past nine P. M. The direction appears to have been from a point between north and northeast. It was also felt at sea north of Cape Mendocino. At Red Bluff and at Eureka, California, and at Albany, Oregon, two shocks were reported, and at Roseburg, Oregon, a "roaring" was also heard.

Dec. 3, 1873.—A sharp shock in Santa Clara, California.

Dec. 4, 1873.—Two severe shocks in the morning at St. Thomas, West Indies.

Dec. 10, 1873.—A slight shock reported at Camp Stambaugh, Nebraska.

Dec. 17, 1873.—A smart shock, followed by a rumbling noise, between 11 and 12 P. M., at Victoria, Vancouver's Island.

Dec. 18, 1873.—A heavy shock at sunrise in Bear Lake Valley, Utah.

Dec. 20, 1873.—A shock in the night, lasting ten seconds, at Victoria, Vancouver's Island.

Jan. 5, 1874.—A slight shock about 4 P. M. at Ogdensburg, New York, and vicinity. It was also felt at Rensselaer Falls, where it was attended by a "deep rumbling sound."

Jan. 18, 1874.—Two slight shocks in San Francisco.

Jan. 25, 1874.—A slight shock about noon at Chelmsford, Massachusetts.

Feb. 1, 1874.—Two shocks between 2.30 and 3 P. M., at Rimouski and a few other points on the St. Lawrence River.

Feb. 6, 1874.—A severe shock at La Guayra, Venezuela, causing much injury to persons and property.

My thanks are due to E. L. Gaul of the New York Times, for information received.

New Brunswick, New Jersey, Feb. 24, 1874.

ART. XXXV.—*Geographical and Geological Explorations and Surveys West of the 100th Meridian;* First Lieut. GEO. M. WHEELER, Corps of Engineers, in charge.

THE labors of the Survey, which has for its objects examinations in the departments of astronomy, topography, meteorology, geology and natural history, have been divided into two distinct parts, so far as they refer to the field-season of 1873. The parties have been engaged in the following political divisions: 1st, Colorado; 2d, New Mexico; 3d, Arizona; 4th, Utah; 5th, Nevada; 6th, Montana. The first part or main division includes astronomical work at the main field-stations, which, after having been prosecuted across a sensibly latitudinal belt of country, from Omaha to San Francisco, will gradually be developed laterally into what might be termed a scheme of astronomical triangulation. At each of the stations, bases are measured upon which are founded a system of secondary triangulation, which is further extended by trigonometric connection over specified areas. Three parties connected with this portion of the work commenced their field duties June 1st. One party, which was in charge of John H. Clark, astronomer, took station at the Mormon observatory in Temple square, Salt Lake City. Mr. Clark was assisted by two soldiers of the battalion of engineers. The second party, under Dr. F. Kampf, astronomical observer, commenced operations at Georgetown, Colorado. Dr. Kampf was assisted by one civilian as recorder and by two engineer soldiers. A third party, in charge of W. W. Maryatt, assistant astronomical observer, recommenced the series of observations at Green River, on the Union Pacific Railroad, Wyoming, left unfinished in 1872. Mr. Maryatt had also for his assistants one civilian recorder and two engineer soldiers. Prof. T. H. Safford, whose services had temporarily been secured, through the courtesy of Major Barlow, Corps of Engineers, took charge, with due military assistance, of astronomical party No. 4, at Santa Fé, New Mexico, on or about June 15th. The general charge of the construction of the astronomical observatory at Ogden, Utah, in accordance with the plans proposed, was delegated to Prof. H. B. Herr, of Lehigh University, Pennsylvania. The observatory was completed, with the exception of the dome, and consists of a substantial brick building upon a stone foundation, with three observing rooms, which may be increased to five in number. This will serve as a central or connecting station for a great share of the area between the 49th and 32d parallels of latitude, limited on the east by the continental divide, and with the general Sierra Nevada trend of mountain ranges as a western limit. The main line of the Western Union Telegraph Company now connects with the observatory, and without difficulty, lines reaching either to the north or to the south can be obtained. At each of these stations a heavy stone pier is erected; also other stone monuments to mark the meridian of the place. Up to the close of the last field-season, twenty-four distinct meridian lines have been determined by the Survey in different parts of our western country, independent of the large amount of astronomical work necessary for minor checks. Local surveys are conducted in connection with this class of work, and the results are to be incorporated into the general map.

The observations necessary for the accurate determination of the astronomical coördinates of the following positions were completed.

1. **Santa Fé, New Mexico.**
2. **Fort Union, New Mexico.**
3. **Trinidad, Colorado.**
4. **Labran, near Cañon City, Colorado.**
5. **Colorado Springs, Col.**
6. **Hughes, Colorado.**
7. **Georgetown, Colorado.**
8. **Ogden, Utah.**
9. **Winnemucca, Nevada.**
10. **Virginia City, Nevada.**
11. **Bozeman, near Ft. Ellis, Mon.**
12. **Green River, Wyoming.**

It may be hardly necessary to add that the signals for the longitude are made by the use of the telegraph. The series of observations required for latitude and longitude work are by the aid of the best class of field astronomical instruments, and the results already computed prove that the probable errors obtained are a minimum.

The second main division of the Survey consists of the moving field-parties. Its *personnel*, in addition to the officer in charge, has been three other officers of the Corps of Engineers, two officers of the line of the army, two acting assistant surgeons, one hospital steward, seven topographical assistants, three meteorological assistants, three geological assistants, one mineralogist and three natural-history collectors. Their labors comprehended exhaustive work in topography, and examinations in geology and natural history, so far as the administration of the survey will permit, besides a series of general meteorological determinations, which were made hourly at the main astronomical stations. The duty of making sextant astronomical observations, for resultant checks to topographical positions, is delegated to officers of the Corps of Engineers connected with the Survey.

Our points of departure to the field of operations were three in number: 1st, Salt Lake City; 2d, Denver, Col.; 3d, Santa Fé, N. M. The party at Salt Lake took the field about May 20th. The duties assigned to this party were to complete certain areas upon specified atlas sheets, left incomplete in 1872. Although meeting with many physical obstacles, after an harrassing campaign, they accomplished their work in Utah, and carried out the duties assigned to them in the southern part of the survey. Their topographical notes have been received and are already in the hands of the lithographer. Lieut. R. L. Hoxie, Corps of Engineers, had charge of this division. Lieut. W. L. Marshall, Corps of Engineers, had charge of the Colorado party. This party, assisted by the coöperation from the southern portion of the Survey, has accomplished the general profile of the continental divide, from the latitude of Denver to the southern boundary of Colorado, and extended the survey laterally, so as to embrace a rectangular area limited on the east by the 105th meridian west from Greenwich, on the west by longitude 107 degrees, north by the latitude of Denver and south by the southern boundary of Colorado. A large part of the expedition was massed at Santa Fé, and took the field between the 5th and 10th of June, for the purpose of connecting with the labors of the expedition of 1871, and to carry the survey thence eastward as far as the Rio Grande, between the latitudes 35° 30′ and 35° 20′ north, completing atlas sheets 75, 76 and 83 respectively, and portions of 77 and 84. The several moving field-parties had for escorts enlisted men, from seven to ten in number for each party, drawn from the military departments of Arizona, the Missouri and the Platte.

While the field operations were being prosecuted, the *personnel* of the office, consisting of three draughtsmen and one computer, has also been kept actively engaged. Astronomical computations have also been made during the season by Prof. Wm. A. Rogers, of Cambridge, Mass. The areas traversed and covered by the various parties will exceed 70,000 square miles. This covers parts of Colorado, Utah, Arizona and New Mexico, and resulting maps are to be completed on a scale of one inch to eight miles. The labors of the season, covering as they do large geographical areas heretofore little known, will add most valuable new and interesting facts to the geography of our western country. Among the most remarkable of these will be the approaches to the cañon of the Colorado, in the vicinity of the Dirty Devil and San Juan Rivers; also features of the Castle Valley in Utah. These form part of the Grand Colorado plateau and present uncommon topographical features. In the vicinity of the Sierra Blanca Range in Arizona, about the head waters of the Little Colorado and Salt Rivers, the main northern head of the Gila and of its tributaries, a section of country both novel and beautiful in its physical characteristics, has been entered. A large part of this territory had scarcely been traversed by any adventurous white man, at least we have no recorded information to that effect. About the head waters of the Colorado, Chiquito and Salt Rivers a system of parks has been developed, that will probably be found to equal, in beauty and grandeur, any yet discovered upon the North American continent within the limits of the United States. This little known section is well wooded, bountifully supplied with water, and covered with a rich growth of the bunch and gramma grasses. The Colorado party was most successful in its topographical and other determinations, over an area of nearly 20,000 square miles in Colorado. Positions have been determined with accuracy, and the amount of topographical detail gathered will supply all that can be placed upon a map of the scale intended. The backbone of the continent within the latitudinal areas traversed is most wonderfully intricate in its topographical and geological forms. The collections in natural history, especially in the departments of ornithology and botany, have been large, and consist of many rare specimens. They are now, through the kindness of the Smithsonian Institution, in the hands of eminent specialists and scientists for examination, and reports upon them are being prepared.

Publications.—During the present year, the first publication of the topographical atlas up to date will be made. This comprises several physical sheets, and covers areas of more than 70,000 square miles, delineated upon a scale of 1″ to 8 miles. A part of the geological atlas, for which material has been gathered, it is hoped will be published in due time. The six quarto volumes prepared for publication are as follows: 1. General volume; 2. Astronomical report; 3. Meteorological; 4. Geological; 5. Paleontology; 6. Natural History. Four of these volumes are now well advanced, and it is hoped that they may all be published within the coming year. They will embrace, besides reports of certain officers and assistants of the Survey, special reports upon paleontology and certain natural history subjects, contributed by gentlemen who have examined the fossils and other collections.

Art. XXXVI.—*On a Mass of Meteoric Iron of Howard Co., Ind.; with some remarks on the molecular structure of meteoric iron, and a notice concerning the presence of solid protochloride of iron in Meteorites;* by J. Lawrence Smith, Louisville, Ky.

The mass of meteoric iron described below possesses peculiar interest from the fact that it was not found on the surface of the ground, but beneath the soil, although not to any very great depth. In 1862, a farmer, Mr. E. Freeman, while excavating a ditch in Howard County, Indiana, struck, at a depth of nearly two feet, a hard mass that attracted his attention; and owing to its unusual weight, he preserved it. The earth penetrated consisted of stiff clay beneath four inches of black soil, so that the mass was imbedded in the clay. This clay was colored by oxide of iron, arising from a slight decomposition of the surface of the meteorite, the iron being one of those that decomposes but slightly from atmospheric agencies. This meteorite was lost sight of for a number of years, having fallen into the hands of those not interested in matters of natural history, and only recently was sent to me for examination.

The form of the meteorite is an irregular elongated oval, and it has the indentations of the surface found on most meteoric irons. Its weight is four kilograms. The alteration at surface is very slight, considering the length of time it must have remained beneath the surface of the soil, and fresh cut surfaces retain perfectly their brightness. The specific gravity is 7·821.

The composition of the meteorite is as follows:

Iron	87·02
Nickel	12·29
Cobalt	·65
Phosphorus	·02
Copper	*a trace.*

A polished surface, when treated with nitric acid or bromine water, does not give the slightest indication of Widmanstättian figures, so characteristic of most meteoric irons. It hence belongs to that class of irons which are rich in nickel and yet give no signs of such figures, to which belong the Cape of Good Hope iron of 1793, containing 15 per cent of nickel and 2·5 per cent of cobalt, and also a more recent California iron, called the *Shingle Springs* iron, containing 17 per cent of nickel and ·6 of cobalt. Of the same kind is the Octibbeha meteorite, containing the very large amount of 59·7 per cent of nickel. Besides the above, there are certain irons containing much less nickel that are also without these figures, as the Nelson County, Braunau, etc.

The phenomena of the so-called Widmanstättian figures in connection with meteoric irons is one of considerable interest, and as yet escapes a satisfactory explanation. At one time it was supposed to arise from the accumulation in the lines of the figures of an alloy richer in nickel than the mass of the iron. Then, again, it has been supposed to arise from the accumulation of a phosphide of nickel and iron (schreibersite), along certain lines of crystallization in the mass. But neither of these hypotheses serve to explain the varied features of these figures, or the total absence of them, as in the present instance. My own conviction is, that we shall not arrive at a satisfactory explanation until our knowledge of the effect of a minute quantity of foreign substances in the iron is better understood than now; a subject which both pure and technical chemistry are now studying with great interest, in order to discover how far those substances usually called impurities in iron are to be regarded as hurtful. The tendency of the investigations at the present time is to show that these supposed impurities may all play an important part in useful modifications of iron, when present even in very minute quantities; and I would state, as the result of my observation (and one bearing upon the present question), that one per cent or less of phosphorus so far modifies cast iron that it will resist the action of concentrated sulphuric acid to a greater degree than when entirely free from phosphorus. This fact explains why it is that those who separate silver and gold by what is known as the sulphuric acid process, have to make trial of many descriptions of cast iron before they can get one well adapted to their purpose; some cast-iron vessels being destroyed in a few weeks, while others will last for years. It is true also, that, besides any chemical property which the trace of phosphorus may impart, it modifies to a certain extent the physical properties, imparting to the iron more fluidity when in a melted state, and furnishing more compact castings. My present conviction in regard to the Widmanstättian figures is that, in the consolidation and crystallization of the iron, as in the crystallization of all other substances containing impurities, there is a tendency to eliminate the foreign constituents, to the exterior portion of the crystals; and, where the mass becomes a conglomeration of crystals, it is between the crystals, and contiguous to their surfaces, that we shall find the great part of the foreign constituents, mixed with more or less of the predominating materials. In the case of iron, we often see this in a very marked degree: as, for instance, where a blast-furnace has been chilled, and the accumulated iron at the bottom passes slowly from a plastic to a solid condition, there the iron will be found in large crystals containing a very much smaller amount of carbon than in that usually produced by the furnace, the carbon having been eliminated in the form of flakes of graphite between the crystals.

To apply this reasoning to meteoric irons (which, according to experiments made by me in 1852, on eighty specimens, and verified by all my subsequent analyses, always contain phosphorus), it might be safely premised that, should the iron be consolidated rapidly, we might expect such a diffusion of the phosphorus as to give no marked indications in any parts of the mass. If, however, the iron has passed slowly from the plastic to the solid condition, we might expect a more or less perfect elimination of the phosphorus in certain parts representing the spaces between the crystals of the mass. It must not be supposed that its complete elimination always takes place in the form of a definite compound of phosphorus and iron, but that the portions of the iron forming the limits of the crystals become more richly charged with phosphorus, from the center to the circumference of the crystals, during the slow consolidation of the latter. The result of this phenomenon would be to destroy the homogenous character of the mass, and consequently to render its different parts variously susceptible to the action of chemical agents. Thus, an acid would act in one part on the iron more readily than in another, affecting the least that part containing most phosphorus, even though this last element should be in very minute quantity, and so producing that mottled surface in the lines of crystallization known as the Widmanstättian figures.

Of all examples of the separation of substances in the formation of natural compounds, there are none comparable to those exhibited by meteoric irons, in which elements having a most remarkable affinity for each other are separated the one from the other by the sharpest possible lines. Of course, I do not mean by this that the sulphur, phosphorus and iron of a meteorite are completely separated the one from the other, but that a small portion of the iron will combine with nearly all the sulphur and phosphorus of the entire mass, segregating in clear and distinct nodules, and in a manner that it would be vain for us to attempt to produce artificially.

One of the most remarkable forms of this segregation is where the sulphur and phosphorus compounds are eliminated into the same cavity, as was first shown by me in 1852. I have in my possession (and the same may be found in other cabinets) several examples of this. The last one which has come to my notice is that of the iron which fell in South Africa in 1862, and which I described in a recent number of this Journal. In this iron there is an oval cavity, two and a half centimeters in its long diameter; at the center is troilite (sulphid of iron), filling the cavity to within one or two millimeters of the surface; and between the exterior surface of the troilite and the inner surface of the cavity is a thin layer of schreibersite (a phosphuret of iron and nickel of definite composition) (Ni^2Fe^4P), with hardly a trace of sulphur. In other places in the iron, we find laminæ of this same phosphuret, of greater or less thickness; nodules of troilite are also frequently found entirely alone. But, it may be asked, what of the iron which contained this large amount of phosphorus and sulphur disseminated through the mass? Now in the iron proper there is to be found only a trace. In the Tazewell iron, for instance, which furnished me several of these compound nodules, there is but ·016 per cent of phosphorus, and in the Arva iron, filled with layers of schreibersite, the iron itself has remaining in the mass only ·019 of one per cent: and it seems to me impossible to explain such perfect elimination of phosphorus and sulphur, substances having so strong an affinity, except by supposing a long plastic condition and slow consolidation of the mass.

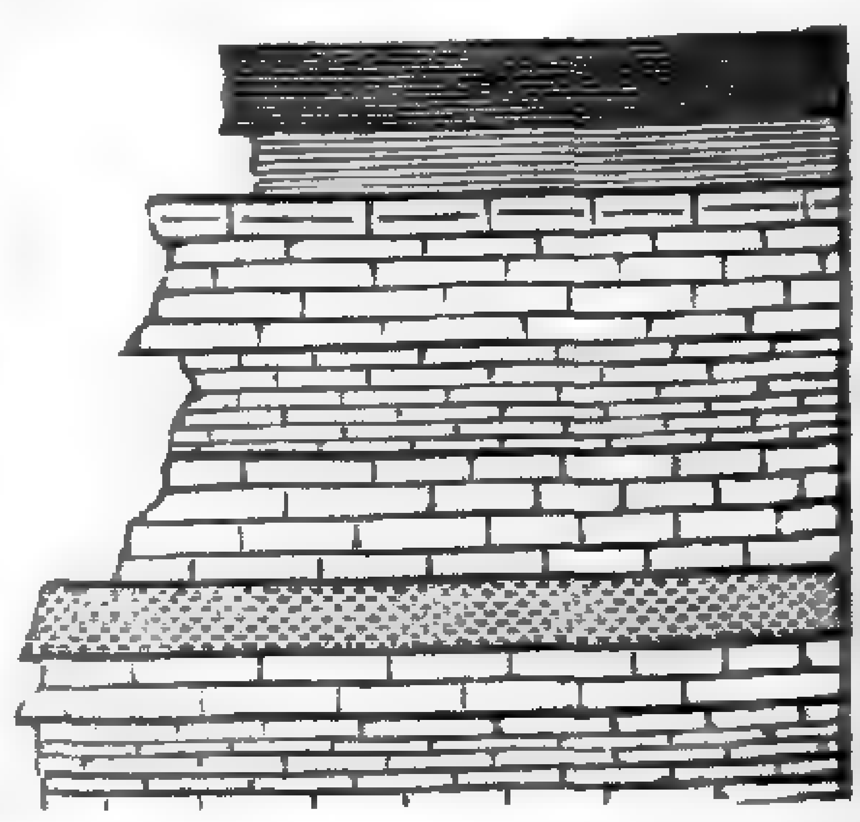
It is almost needless for me to say that geologists and mineralogists have noticed this process of segregation in a vast number of cases. In fact, it is one of those processes which assist in a conspicuous manner in the formation and separation of rocks and minerals; and I only give to it greater prominence here from the fact of the great affinity of the subtances taking part in the production of this phenomenon in meteoric irons. These views are put forth, not so much to give expression to positive conclusions on this subject, but rather to give a proper direction to the method of studying this question.

Solid protochloride of iron in Meteorites.—In 1852 I detected for the first time small particles of solid protochloride of iron in the Tazewell iron; for, although the exudation of a deliquescent salt has been frequently observed on the surface of these irons, it has always been found due to a liquid perchloride, and its exact source in the iron has never been traced, so that many have supposed that this perchloride was of terrestrial origin. But the discovery of the solid protochloride in the interior of the mass was sufficient to establish beyond doubt that the chloride formed a part of the original mass of meteorites. Since that time, no mention has been made of a further discovery of this protochloride; and it is only within a few months that I found it a second time, in the meteoric iron from Rockingham County, North Carolina. It was in the form of a small green mass. After removing it from the interior of the iron, a small portion of it was used for a qualitative analysis, and the remainder placed in the hands of Prof. Daubrée, of the School of Mines at Paris. With these remarks I conclude all that I have to say in this chapter on the chemical study of this interesting class of bodies, which link the earth to distant cosmical bodies.

ART. XXXVII.—*On the Hamilton in Ohio;* by N. H. WINCHELL.

THE following summary is taken from a report on Paulding County, in northwestern Ohio, written for the Geological Survey of that State. In the progress of the survey of Delaware County, some evidence was obtained of the Hamilton age of the whole of the blue limestone of that county, but not such as placed an opinion beyond the limit of doubt. Hamilton fossils are found in it in various places. The same is true of its exposures in Marion and Seneca, and at Bellevue in Sandusky County. But in Paulding County the closest attention was paid to the solution of the question, "Do Hamilton fossils extend through the whole of the blue limestone?" a question propounded by the Director of the survey, for the purpose of testing the evidence. It is deemed best here to present a general section of the rocks of Paulding and Defiance Counties, in order to express clearly the position of the beds that have furnished the writer the only Hamilton fossils found in northwestern Ohio. This section agrees in all its details with that of Delaware County, except the attenuation here of the Olentangy shale of Delaware County. Indeed, this shale, which in the Report of Progress for 1869 is regarded *Hamilton*, is seen to be entirely wanting in most places in Defiance County, the thin, tough, Black Shale layers lying immediately on the hard beds of the Tully limestone.

Diagram showing a section of the rocks of Paulding and Defiance Counties, Ohio.



No. 1. *Huron shale*, of the Ohio Reports. No. 2. Bluish shale, local; the *Olentangy shale* of Delaware County. No. 3. Hard, dark-blue siliceous limestone, the *Tully limestone* of New York. No. 4. Blue limestone; the whole, including the lowest observed part of this, holds Hamilton fossils, the *Hamilton limestone* of New York. No. 5. Saccharoidal, very fossiliferous limestone: the *Delhi beds* of Delaware County; the *Corniferous limestone* of New York. No. 6. Buff, magnesian limestone; the upper half is in thin beds; the *Onondaga limestone* of New York. No. 7. Sandstone; conglomeritic in Delaware County; the *Oriskany* of New York. No. 8. Heavy-bedded, magnesian limestone; "phase No. 2," of the *Waterlime;* Ottawa County. No. 9. Thin, wavy, compact beds, "phase No. 3," of the *Water-lime;* Ottawa County.

No 1 of this section does not appear in Paulding County, except in the form of floating pieces transported with the Drift. It is fully described in reports on other counties.

No. 2 appears in the Tiffin River at Brunersburg, where it embraces a shaly limestone which crumbles under the weather. Such limestone is in detached lumps and lenticular masses. It is washed out of the shale near Waldo, in Marion County, by the force of the water of the Olentangy, where it falls over a dam. It is entirely unfossiliferous, as well as the shale in which it lies. In northwestern Ohio, No. 2 is very much reduced from its observed thickness in Delaware County (30 feet), and is usually altogether wanting. It is evenly but very thinly bedded, and is closely related to the Huron shale (No. 1), with which it is interstratified in Delaware County.

No. 3.—This holds the place and exhibits most of the characters of the Tully limestone of New York. Its identity is not established on paleontological evidence. It is quarried at Florida, on the Maumee, and by Mr. Dilz, near Defiance. At the former place, it is immediately overlaid by the Black Shale. Its thickness is 6–10 feet.

No. 4 has a thickness in Delaware County of thirty-five feet, and probably it will not vary very much from that, on the west side of the anticlinal. There are no exposures in these counties favorable for learning its aggregate thickness. In the season of 1871, a collection of fossils characteristic of the Hamilton was made in the northeast ¼ sec. 30, Auglaize, in Paulding County. The species here gathered were those already enumerated in the description of the outcrop at that place.* Time was not sufficient then for determining certainly the relation of this stone to the rest of the blue limestone. In the season of 1872, this point was made the subject of careful investigation. The result arrived at was the conclusion that the beds which hold these Hamilton fossils are very near the bottom of the blue limestone. The evidence is not that of actually observed superposition, but that which is based on a series of observations, along the Auglaize Valley, on the *dip* of the underlying rocks. It is a very observable fact that the limestones of northwestern Ohio are very evenly and regularly laid down, and have not been so disturbed by any force as to introduce exceptional or even extraordinary dip, in any direction or degree. In passing along the valleys of any of the streams that expose the rock, this fact is very apparent. The formations succeed each other in perfect conformity with the known general dip. It is so in Paulding County. The Water-lime, the lowest in the series of rocks in the county, occupies the most southerly part of the county. Its upper horizon unites with the Oriskany at Charloe. The dip is very slight, but to the north. In regular order, and a little farther north, the Onondaga beds of the Corniferous group appear. Next, the Corniferous proper appears at the mouth of the Flatrock, with dip northeast. About three-quarters of a mile still farther north occurs the outcrop which holds the abundant Hamilton fossils, the dip there being in the same direction and to the same amount. This is at the mouth of the Little Flatrock. A half mile still farther north is Mr. Mead's quarry in the blue limestone of Delaware, the dip being the same. A few rods still farther north is Mr. Columbia's quarry, in the beds of the same, or nearly the same, horizon. About three-quarters of a mile still farther north, the blue limestone is again quarried, sec. 17, Defiance, Defiance County, where the dip is still north or northeast. About a mile and a half still farther, the Tully limestone comes into view, and is wrought by Mr. Dilz for lime. A mile still farther, the Black Shale appears. Throughout the whole of this distance, there is no return of the strata by an exceptional dip. The beds occur in exactly that order they should have if laid regularly down, like the shingles on a roof.

* They are *Atrypa reticularis*, *Cyrtia Hamiltonensis*, a handsome *Orthis*, *Spirifer mucronatus*, *Spirifer* (a large species resembling *S. macrothyris* H.) *Terebratula*, *Strophomena*, *Cyathophyllum*, *Aulopora*, *Calopora*, and various fine incrusting corals.

The inference is inevitable that the lowest layers occur in outcrop farthest south. Now, as there is no blue limestone exposed to the south of the mouth of the Little Flatrock, and since there are, on the other hand, abundant exposures to the north, the dip being, as stated, constantly to the north, the rock at the Little Flatrock, containing the Hamilton fossils mentioned, must lie below the rest of the blue limestone observed, and very near the bottom of that formation. There can be no other evidence except that of actually observed superposition. The writer did not give strict attention to the subject of the downward limitation of well-known Hamilton fossils in the survey of any other county, having regarded the uniformity of lithological characters sufficient to establish the essential unity of the whole of the blue limestone, and never having noticed a lack of corresponding uniformity of paleontological characters. These latter were sufficient to indicate the Hamilton age and the perfect parallelism of the blue limestone with the Hamilton limestone of the adjoining State of Michigan.

No. 5 is that which is seen in the Auglaize near the mouth of the Flatrock. It is much different from the blue limestone in lithological characters. It is not so hard, nor so dark-colored. The beds are generally of about the same thickness as those of the blue limestone, but much less uniform. They are apt to taper toward the right or left, and appear as lenticular pieces. Their upper surfaces are also roughened by prominent fossil corals. The rock is much freer from argillaceous matter than the blue, and makes a whiter quicklime. It is sometimes crinoidal; and its mural faces in Delaware County present an apparently massive structure, with crumbling surfaces, the pieces falling out being an inch or two in diameter. Its thickness is about twenty-eight feet.

No. 6 has a thickness of about thirty feet. Its upper portion is thin-bedded, and fit only for quicklime. Its lower portion is in heavy beds of twelve or fifteen inches, and is in some places a prized building stone. It is of uniform grain and composition, being non-fossiliferous, and is susceptible of being cut or sawn into blocks of any desired dimensions. It often passes for a sandstone, and has a light cream color when weathered.

No. 7 is perhaps ten feet thick; but only six inches have been seen in Paulding County. It is sometimes conglomeritic. Several large boulders derived from it were seen in the bed of the Maumee, near Emerald.

No. 8 is from six to ten feet in thickness. The quarry at Charloe is in No. 8.

No. 9 is in wavy, or at least in distorted, bedding, a common feature of that phase of the Water-lime.

ART. XXXVIII.—*On the Lignites and Plant-Beds of Western America;* by J. S. NEWBERRY.

IN the Geological Report of Prof. F. V. Hayden for 1872, Mr. Leo Lesquereux gives a comprehensive review of the fossil flora found associated with beds of lignite, in various localities through the western portion of our continent. The views advanced in this paper are so inconsistent with the facts observed by myself, that I venture to call in question the accuracy of some of them. By Mr. Lesquereux, much the greater part of the fossil plants found at the west are referred to the Eocene, whereas, to my certain knowledge, a considerable portion of the flora which he calls Eocene is Cretaceous, and another considerable portion is of Miocene age. This question will be discussed in a report on the fossil plants of New Mexico, Dakotah, Oregon, etc., which I am preparing for Prof. Hayden, and I will now only allude to some of the facts which are incompatible with Mr. Lesquereux's views.

The earliest and best known of the plant-beds of the far west are those of the region of the plains, in Nebraska, Kansas and the Indian Territory, of which those of Black Bird Hill, Fort Harker, Walnut Creek and Whetstone Creek may be taken as examples. These were at first pronounced by Prof. Heer to be Miocene, and in this view he was defended by Mr. Lesquereux, while I asserted that they were Cretaceous.* It is now universally conceded that the latter view was correct. From this horizon, we have obtained a large number of fossil plants, and this, the first angiospermous flora known, has proved to be of great richness and interest. It has, however, passed out of discussion, and requires no further notice here.

During my explorations of New Mexico and Arizona, I found beds of lignite at various localities; those of the San Juan, for example, attaining a thickness of from thirty to fifty feet. With these lignites are many fossil plants. Dr. Hayden, who in 1869 made a reconnaissance as far south as Santa Fe, touching these plant-beds on Galisteo Creek, referred them to the Tertiary. Following him, Mr. Lesquereux has reported all the New Mexican lignite and plant-beds to be of Eocene Tertiary age. Having spent nearly two years in this region, constantly occupied in the study of its geology, I feel authorized to state that all the lignite beds yet known in New Mexico are unmistakably of Cretaceous age. Fossil plants are found at several different horizons in the Cretaceous, but none whatever in the Tertiary. In fact, the only Tertiary strata known in

* This Journal, vol. xxviii, p. 85; xxix, pp. 208, 434.

New Mexico are the chalky fresh-water marls deposited in basins of the present topography, and without fossil plants.

The lignites of Colorado, which are so largely developed in the Raton Mountains, at Trinidad, Golden, Marshall's, etc., have been studied by Mr. Lesquereux in place, and by him they, with their associated plant-beds, are regarded as constituting typical examples of our American Eocene deposits. As I have not visited that portion of Colorado where this great lignite formation is exposed, I will not venture to deny the truth of the conclusions arrived at by Mr. Lesquereux. I may say, however—1st, That the flora of these Colorado lignite-beds has almost nothing in common with that of the European Eocene. Its botanical aspect is certainly entirely different, and, in my judgment, not a single species and scarcely any genera are found in both. 2d, That the tuberculated fucoid (*Halymenites*), considered by Mr. Lesquereux as diagnostic of the Eocene, is in New Mexico the most characteristic fossil plant of the *Cretaceous* sandstones. 3d, That Profs. Meek, Marsh, Cope and Stevenson, guided by the molluscous and vertebrate remains found in the Colorado lignite deposits, consider them Upper Cretaceous.

The age of the lignites of Wyoming and Utah—of Carbon Station, Rock Springs, Coalville, Hallville, Evanston, Bear River, &c.,—has been discussed at length by Messrs. King, Emmons, Meek and Cope. While it is admitted by all that there are wide-spread Tertiary deposits in Wyoming and Utah, and some of them contain lignite and fossil plants, it is claimed and apparently proved, by the gentlemen whose names are cited above, that the lignites of the localities named are Cretaceous.*

In regard to the Bitter Creek lignites, Mr. Meek shows that the evidence, if not conflicting, is at least indecisive of their age.

The strata of Wyoming, which contain the newly discovered and wonderful vertebrate fauna described by Profs. Leidy, Marsh and Cope, are thought by these gentlemen to be clearly Eocene. But, though so rich in animal remains, they contain few plants, and these throw little light on the discussion. The Green River plant-beds are placed by Mr. Lesquereux in the Miocene; but a small group of plants which I have from these beds includes palms (*Manicaria*) and other plants not found elsewhere in the Miocene of America. Mr. Lesquereux is disposed to regard palms as diagnostic of Eocene, but they are common enough in the Miocene of Europe, and they should have grown in Wyoming when the luxuriant Miocene flora covered Alaska and Greenland.

* A very comprehensive review of the question is given by Mr. F. B. Meek in the chapter of Prof. Hayden's Report which succeeds the paper of Mr. Lesquereux.

From the great lignite basin of the Upper Missouri, a large number of fossil plants have been brought to me by Prof. Hayden, the Sully expedition and others. Many of these have been already described, and the flora which they represent I have pronounced Miocene.* In the review to which I have alluded, Mr. Lesquereux refers all the plants from the Upper Missouri lignite-beds to the Lower Eocene. This conclusion I am unable to accept, from the fact that the general facies of the Missouri lignite-flora is altogether unlike that of the European Eocene, and it is identified with the Miocene flora of Arctic America, Iceland, the Hebrides and Central Europe, by most of its genera and by a considerable number of well-marked identical species. It also contains some species which are living at the present day. Among these latter may be mentioned our deciduous cypress (*Taxodium distichum*) and the sensitive fern (*Onoclea sensibilis*). This fern also occurs in Greenland, and is that described by Edward Forbes, from the plant-beds of the Island of Mull, under the name of *Filicites Hebridicus.* Among the plants common to the Upper Missouri lignite-beds and other well known Miocene deposits, are *Corylus McQuarrii* Forbes, *Glyptostrobus Europæus* Ung., *Sequoia Nordenskioldi* Heer, *Carya Antiquorum* Newb., (=*Juglans nigella* Heer), *Populus cordata* Newb., (=*P. Zaddachi* Heer), *Taxites occidentalis* Newb., *Thuia interrupta* Newb., etc.

The coals and fossil plants of Vancouver's Island are stated by Mr. Lesquereux to be of Tertiary age; but the evidence that they are Cretaceous is overwhelming. Some of the species found in the locality were at first supposed by Prof. Heer and Mr. Lesquereux to be identical with European Miocene species, but we now know that this identification was made upon insufficent evidence. Among the fossil plants which I have seen from Vancouver's Island, there is only one which I can certainly identify with a species found elsewhere, and that is *Sequoia Reichenbachi*, which occurs in numerous localities in the Cretaceous of Europe and in the Arctic. The Cretaceous age of the Vancouver coal was known to me as early as 1858, when I received the first collections made there by the late Mr. George Gibbs, and it was demonstrated in the paper on the fossils collected by him, published in the Proceedings of the Boston Natural History Society, in 1863. Interstratified with and overlying the beds of coal at Nanaimo, are strata containing great numbers of well marked Cretaceous mollusks, *Ammonites, Baculites, Inoceramus*, etc. With our present knowledge of paleontology, very few geologists would consider the question of the age of strata which contain these genera open to discussion.

* "Our Later Extinct Floras"—Annals Lyc. Nat. Hist., N. Y., vol. ix, 1868.

The plant-beds of Birch Bay, from which collections were made by Prof. Dana, when connected with the U. S. Exploring Expedition; those of Burrard Inlet, and those of Eastern Oregon, from which such extensive collections have been made by the Rev. Thomas Condon, are, in my judgment, all Miocene. The same may be said of those of Alaska and McKenzie's River; at least, in all these, as well as in those of the Upper Missouri, we find species which recur in Greenland, Iceland and continental Europe, in what has been universally called the Miocene flora.

The Eocene flora of Europe, as exhibited in the Island of Sheppey, at Monte Bolca, etc., has a distinctly tropical and Indo-Australian character; and we must say that, up to the present time, no similar group of plants has been found in America. In a botanical point of view, therefore, we are quite safe in the statement that the Eocene flora has not yet been recognized in this country. Looking at the question, however, from a geological stand-point, it assumes a somewhat different aspect. It is certain that we find on this continent Tertiary deposits which correspond in position with the Eocene of the Old World, and these contain many Eocene mollusks. If, now, fossil plants were found associated with these, we should be compelled to regard them as forming an Eocene flora, whatever their botanical character might be; just as our Cretaceous flora is none the less Cretaceous, though somewhat more closely allied to the Tertiary flora than are the plants found in the Cretaceous of Europe. Yet we find, with our Cretaceous plants, great numbers of well marked Cretaceous animal fossils, and these have very properly outweighed the modern facies of our Cretaceous flora. But have we found in or with the plants, supposed by Mr. Lesquereux to form our Eocene flora, any satisfactory internal or external evidence of their Eocene age—that is, have we among them any unmistakable Eocene plants or associated with them any unmistakable Eocene mollusks or vertebrates? So far as regards the central and western portions of the continent, I should say we had not. In the plant-beds which I have regarded as Miocene, the whole aspect of the flora is that of the Miocene of Europe, and it contains a very considerable number of well marked Miocene species, and not one, so far as I know, which deserves to be called Eocene. The lignites and plant-beds of New Mexico which I have called Cretaceous, but which are referred by Mr. Lesquereux to the Tertiary, are for the most part derived from the lower portions of our Cretaceous series, and are overlaid by many hundred feet of strata unquestionably Cretaceous, in which all the typical forms of Cretaceous animal life are abundantly represented. Whether the great lignite deposits of Colorado should be considered Tertiary or Cretaceous, it is perhaps not yet possible to decide; but, in the absence of any distinctive or unmistakable Eocene plants, if the strata which contain them shall be found to include vertebrates or mollusks which have a decidedly Mesozoic character, we shall be compelled to include them in the Cretaceous system. Mr. Lesquereux has met the statements of Profs. Meek, Cope and Marsh, that Cretaceous mollusks had been found in and overlying the Colorado lignite deposits, by pointing to his 250 species of fossil plants, claiming that they far outweigh the testimony of the animal remains. In fact, however, these fossil plants have very little bearing on the question. They are probably all distinct from European Cretaceous and Eocene species, and the genera to which they are supposed to belong afford only negative evidence of the strata that contain them.*

It is by no means insisted that we must find in America the plants of the European Eocene, before we can be said to have an Eocene flora, since, during the Eocene period, the physical geography of Europe was such as to give it a very different flora from any that *ever* grew on the North American continent. During the deposition of the Eocene strata, the great mountain barrier which extends from the Bay of Biscay to the China sea—formed by the Pyrenees, Alps, Carpathians, Caucasus and Himalayas—existed, if at all, only in embryo. The Mediterranean communicated with the Indian Ocean, the south shore of Europe was washed by a tropical sea, and the land was covered with a sub-tropical, Indo-Australian flora. When, however, the great mountain barrier, to which I have referred, was raised, these Austral influences were cut off, the climate of Europe was rendered temperate, and the surface was gradually covered with a temperate flora which, because it included a large number of American plants, *Liriodendron*, *Liquidambar*, *Magnolia*, &c., we may call the *American* flora. This was the flora of the Miocene, of which we have illustration in the fossil plants of Fort Union in Dacotah, Greenland, Iceland, Oeningen, &c. This flora seems to have possessed Europe up to the advent of the ice period. By the advancing cold, it was driven to the shores of the Mediterranean, and there exterminated. When the glaciers were withdrawn, and a milder climate supervened, Asiatic plants seem to have come in and taken possession of the vacant territory. In our country, the history of our vegetation shows no such vicissitudes. From the close of the Triassic period to the present time, our continent has apparently been occupied by plants which form an

* It is an important fact, in this connection, that Lesquereux identifies a number of the species of plants of the Lignite beds with *Miocene* species of Europe. See the last volume of this Journal, page 448.—Eds.

unbroken succession. The north and south reach of our continent has given to the flora a connected belt of territory extending from Central America to the Arctic Sea, over which it could march and countermarch as impelled by alternations of temperature. We need not expect, therefore, to find here any such contrast between the flora of the Eocene and Miocene as is recorded in the Tertiary strata of Europe. Still we have reason to believe that, during the Eocene period, our climate was warmer than during the Miocene, and we may expect to find, in the two floras of the Tertiary, differences of degree if not of kind. In the fruits of the Brandon lignites, in the Palm (*Calamopsis*) and Cinnamon of the Mississippi Tertiaries, and in the palm (*Manicaria*) of the Green River beds, we have, perhaps, some indication of this elevation of temperature and some traces of an Eocene flora. Whatever plants are found with *Zeuglodon cetoides*, *Cardita planicosta*, *Orbitoides Mantelli*, etc., etc., we must accept as Eocene, even should they have no intrinsic Eocene characteristic. So in regard to our Cretaceous flora. While it is altogether new, its varied character and modern aspect simply gives us a new revelation in regard to the vegetation of the Cretaceous world; for, while the fauna of that world contains *Ammonites*, *Baculites*, *Inoceramus*, &c., we are forced to call it Cretaceous. It is not *impossible* that the physical conditions of our continent may have remained so constant that the Cretaceous age faded gradually into the Tertiary. It is not *impossible*, therefore, that we may find some Cretaceous forms of life interlocking with those of the Tertiary age, but truth requires us to say that, up to the present time, *no such connecting links have been found.* The lignites of New Mexico are covered with thousands of feet of sediments, sometimes largely made up of the remains of all the typical Cretaceous forms of life. Possibly in Colorado, beyond the reach of the Cretaceous sea, or where the land was exposed by the retreat of that sea, the Cretaceous flora may have grown on and on into the Tertiary; but as yet we have no evidence of this. Above the lignite beds, a break in the stratification and a conglomerate (Echo Cañon conglomerate) mark the beginning of a new era. Without asserting that this new era was the Tertiary, and the one which had gone before was the Cretaceous, I feel justified in saying that such will probably prove to be the case; or, at least, that no evidence has been yet found which disproves it.

To whatever conclusion, in regard to the age of the plant beds of the west, the facts may lead, when they are all gathered in, that result will be cheerfully accepted by every right-minded man. It is important, however, for the true progress of science, that no conclusion should be accepted until it is sustained by ample proof.

ART. XXXIX. — *Brief Contributions to Zoölogy from the Museum of Yale College.* No. XXVIII. *Results of recent Dredging Expeditions on the Coast of New England.* No. 6; by A. E. VERRILL.

[Continued from vol. vii, page 138.]

BY the coöperation of Professor Benjamin Peirce, Superintendent of the U. S. Coast Survey, the steamer Bache was detailed, during the month of September, to continue the researches of the U. S. Fish Commission, in the deeper waters off the coast, between Mt. Desert, Maine, and Cape Cod. Dr. A. S. Packard and Mr. Caleb Cooke, of Salem, Mass., kindly volunteered to take charge of the dredging operations on the Bache, and made several very successful cruises, bringing back large collections of the Invertebrata of those waters, among which were many arctic forms that were previously unknown on the American coasts. Their collections are particularly rich in those species that inhabit the muddy bottoms that prevail almost everywhere over the deeper parts of the Gulf of Maine, in 50 to 150 fathoms. They also obtained a large collection, of great interest, on the hard bottom, near Cashe's Ledge, in 52 to 90 fathoms. At this place many of the most interesting additions to the American fauna were obtained. Among these were several living specimens of *Anachis Haliæeti* (Jeffreys, as *Columbella*), *Archaster Parelii*, *Antedon Sarsii*, many fine Sponges, etc. Their dredgings may be conveniently grouped as follows:

1. *Muddy Bottoms.*

a.—A series from the muddy bottoms off the coast of Maine, from south of Manheigan Island to nearly south of Mt. Desert, including Jeffrey's Bank and its vicinity, and extending 60 to 65 miles from the coast-line, and covering a region of about 50 miles east and west, in depths ranging from 52 to 118 fathoms. In the following table the dredgings numbered 1 to 18, 22, 23, belong to this region.

b.—Several dredgings made on muddy bottoms in the deep waters near Jeffrey's Ledge, both on the east and west sides of it. (See numbers 20, 24, 24a.)

c.—Two collections of much interest obtained from the deepest waters off the mouth of Massachusetts Bay, 20 to 24 miles northeast from the extremity of Cape Cod, in 117 and 142 fathoms, soft mud. (See numbers 36 and 37.)

d.—Two dredgings made in the central parts of Massachu setts Bay, on muddy bottoms, in 50 and 56 fathoms.

2. *Hard Bottoms.*

a.—A large collection from 52 to 90 fathoms, near Cashe's Ledge, situated about 90 miles south from the mouth of the Penobscot River. (Number 21.)

b.—Several lots from Jeffrey's Ledge, 6 to 14 miles northeast from Cape Ann, in 24–33 fathoms. (Numbers 27–29.)

c.—A large collection from Stellwagen's Bank, situated in Massachusetts Bay, north of Cape Cod, in 22 to 44 fathoms. (Numbers 32–35.)

3. *Inshore, mixed bottoms.*

a.—A small collection made, in 6 fathoms, inside of Baker's Island, Salem Harbor. (Number 26.)

b.—Another from 29 fathoms, off Marblehead. (Number 25.)

The temperatures of the water were taken at most of the localities examined. For the bottom temperatures two Miller-Cassella thermometers were usually employed simultaneously, and the readings of both are generally given in the following table. The great variations frequently observed in using these instruments is certainly very unsatisfactory, and tends to throw doubt upon all the deep-sea temperatures that have been taken by them, both in this country and by the English expeditions.* It is greatly to be regretted that some more reliable instrument cannot be obtained.

Fauna of the Muddy Bottoms.

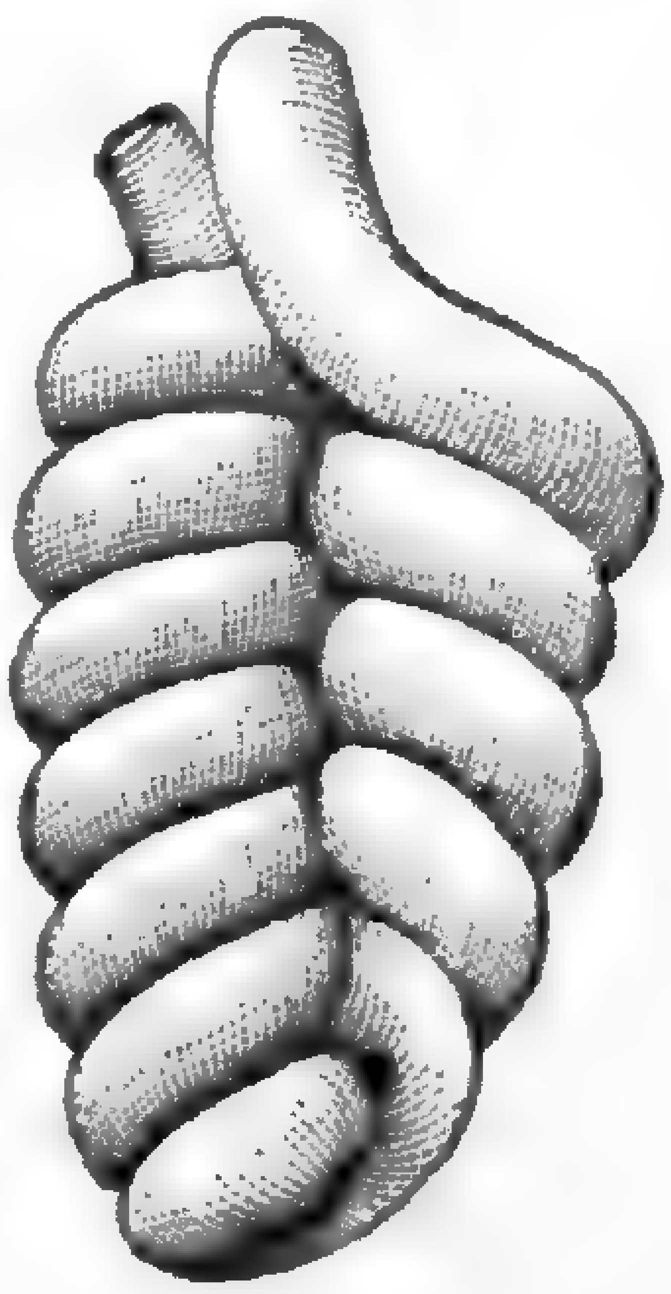
The collections dredged from the muddy bottoms examined during these cruises show a fauna essentially identical with that described in the previous papers of this series as obtained in 1872 by Messrs. Packard and Cooke, from muddy bottoms in 85 to 150 fathoms, near St. George's Bank, and likewise in the Gulf of Maine; and also with those dredged during the past season by our own party, off Casco Bay, from similar depths. The same fauna was also met with by our parties in the deeper parts of the Bay of Fundy, in 1868, 1870 and 1872; and also in the Gulf of St Lawrence by Mr. Whiteaves. Nevertheless, each different region explored presents some peculiarities, or at least affords species that have not yet been found in the other localities. Thus, during the past season neither of our parties have met with *Pennatula*, *Virgularia*, *Ringicula nitida*, *Pleurotomella Packardii*, *Solaster furcifer*, or several other interesting species obtained in 1872, from similar localities and depths. But on the other hand many equally interesting species have occurred this year that were not found

* We have observed not only that the different thermometers will often not agree within several degrees when used together, but the same instrument will not show the same amount of variation at different times, even under identical circumstances, when compared with a standard instrument.

before, and others that were previously rare have been found in abundance.

Among the most interesting Crustacea dredged on the muddy bottoms by Dr. Packard, at localities 36 and 37, are two specimens of a singular crab belonging to the genus *Geryon*, and allied to *G. tridens*, from the deep waters of northern Europe. Our species had been known before only by specimens taken from the stomachs of the fishes caught in deep water, off the coast of Maine. The large shrimp (*Pandalus borealis*) was dredged by Dr. P. in 114 fathoms (loc. 24), and by our party in 50 to 68 fathoms, off Casco Bay. A species of blind shrimp (*Pseudomma*) was dredged in 105 fathoms (loc. 13). This genus was before unknown on our coast, though Mr. Whiteaves dredged a species during the past season in the Gulf of St. Lawrence. *Epimeria cornigera* and *Stegocephalus ampulla* are rare arctic amphipods; and the former was previously unknown on our coast. The curious little barnacle, *Scalpellum Stroëmi* Sars,* had been dredged previously on our coast only by Mr. Smith in 1872, in 430 fathoms, off St. George's Bank, but Dr. Packard found a number of good specimens adhering to hydroids, etc., in 52 to 70 fathoms, near Cashe's Ledge (loc. 21), and also in 142 fathoms (loc. 36). This species likewise occurs only in deep water on the northern coasts of Europe.

1.



Among the Annelids of special interest are *Nychia Amondseni* Malmgren, dredged in 106 fathoms (loc. 18); and *Leanira tetragona* Malm., from 107 fathoms (loc. 9); both new to the American side of the Atlantic; *Grymæa spiralis* V.† (fig. 1, and plate v, fig. 4) and *Enipo gracilis* V.‡ (plate VI, fig. 4) are

* Dr. G. O. Sars has kindly compared a drawing of this species, sent by Mr. Smith, with European specimens, and states that they agree perfectly.

† *Grymæa spiralis* Verrill, sp. nov. (fig. 1, and plate v, fig 4.)

Body long and slender, spirally coiled, composed of over 150 segments, of which about 120 bear fascicles of slender setæ. Branchiæ long filiform, two or three times the diameter of body, arising in three clusters on each side, easily detached and often partially absent. Setæ on the first six or seven segments a little longer than the following ones. General color dark red. Tube (fig. 1) composed of firmly cemented mud and sand, coiled in a double spiral, the two halves revolving in opposite directions.

Off Casco Bay, in 90 fathoms, mud; off Grand Menan I., 60 fathoms; Jeffrey's Bank, 80 fathoms.

‡ *Enipo gracilis* Verrill, sp. nov. (plate VI, fig. 4.)

Body long and slender, quite narrow, the anterior part of the back only partially covered by small oval, smooth, translucent scales. Head rather elongated, tapering; eyes four, conspicuous. Setæ of the lower rami stout, with the terminal portion broad, short cuspidate, and armed with oblique rows of strong, sharp, ascending unequal spines; tips naked, acute, mostly curved.

Casco Bay, 15 to 20 fathoms; Jeffrey's Bank, 80 fathoms.

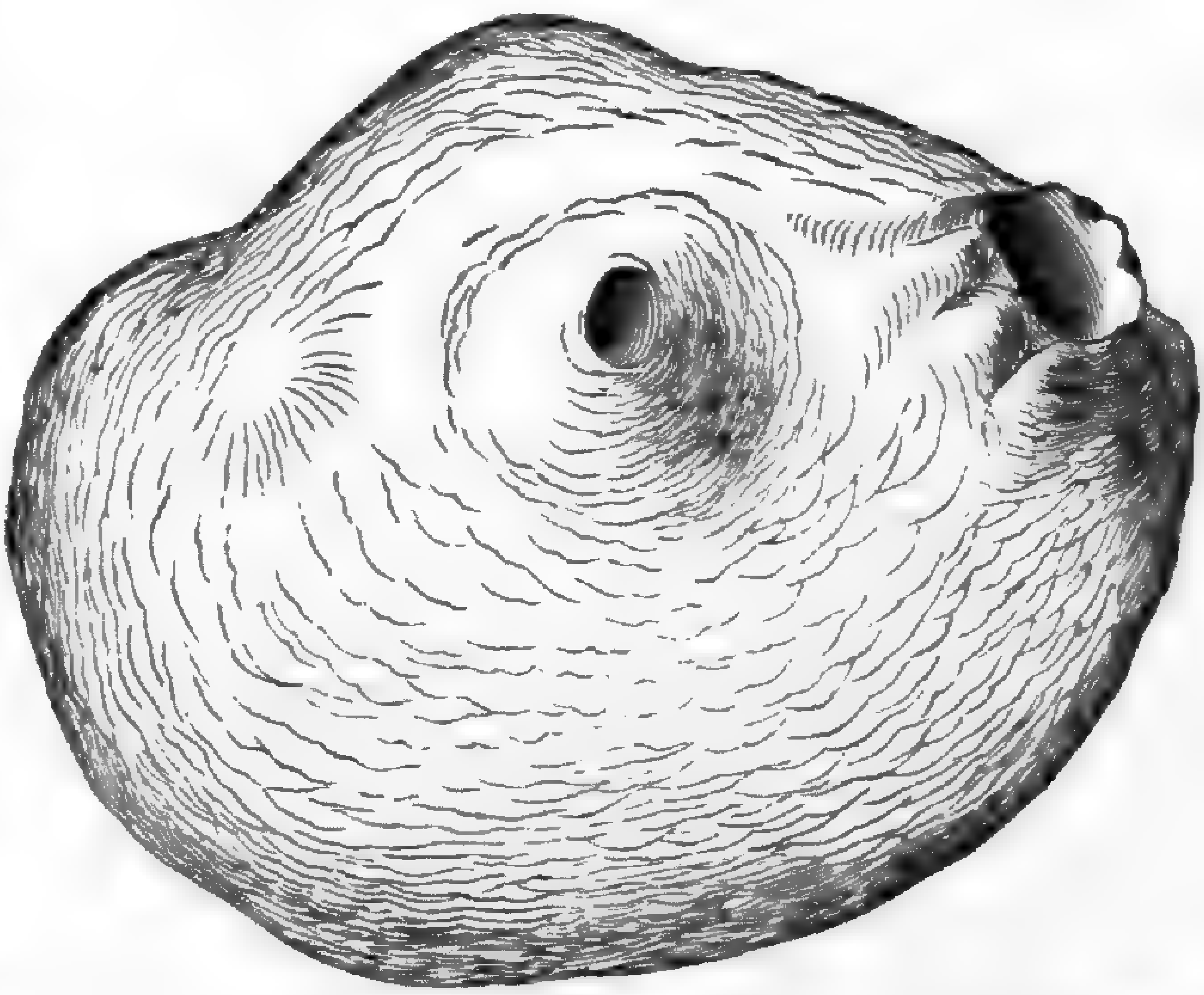
two new species, both from 80 fathoms (loc. 16), and also from Casco Bay. The *Nothria opalina* V. (plate IV, fig. 1) was very abundant on nearly all the soft muddy bottoms, from 50 to 142 fathoms; *Ninoë nigripes* V. (plate IV, fig. 3), *Lumbriconereis fragilis* (plate IV, fig. 2), *Pista cristata* (plate V, fig. 3), and *Chætoderma nitidulum*, were frequently met with.

No.	Locality.	Latitude.	Long.	Nature of bottom.	Depth in fathoms.	Temperature. Air.	Temperature. Surface.	Temperature. Bottom.
1	Off Manheigan Island,			Soft gray mud,	52	58° F.	55°	42 & 44
2	7 m. S.W. from Manheigan I.	43° 39′	69° 22′	Soft mud,	--	58	55	42·5
3	8 m. S. from Manheigan I.,	43 38	69 17	Mud and sand,	64	56	54	43 & 44
4	13 m. S.E. by S. from Manheigan Island,	43 37	69 05	Br'n mud & sand,	60	60	55	43·5 & 45·5
5	17 m. S.E. from Manheigan I.	43 37	68 59	Brown mud,	72	60	54	43 & 44
6	15 m. S.E. from Manheigan I.	43 38	69 01	" "	82	--	--	
7	15 m. S.E. from Manheigan I.	43 38	69 01	" "	82	--	--	
8	18 m. S.E. by S. from Matinicus Rock	43 36	68 32	Mud & gravel,	94	56	55	
9	23 m. S.E. from Matinicus Rock,	43 36	68 24	Sticky br'n mud,	107	56	57	39·5 & 39·5
10	22 m. S.E. by S. from Matinicus Rock,	43 34	68 27	Soft br. mud,	104	56	57	40 & 41
12	Jeffrey's Bank,	43 20	68 33	Brown mud,	60	56	54	42
13	" "	43 23	68 30	" "	105½	58	54	40
14	" "	43 25½	68 40	" "	80	62	60	43
15	" "	43 23	68 44	" "	72½	60	58	42·5 & 47
16	" "	43 19	68 49	" "	79	62	58	40·5
17	S.W. from Jeffrey's Bank,	43 15 5	68 54	Brown mud with gravel,	100	59	57	52
18	S.W. from Jeffrey's Bank,	43 15 5	69 06	Brown mud,	106	58	56	40
20	15 m. S.E. from Boon Island Light,	43 1	70 10	Mud,	95	58	58	37·5 & 40·5
21	Cashe's Ledge,	42 49	68 50	Rocky,	52–90	52	57	43
22	56 m. E. of Cape Ann,	42 52	69 23	Blue mud,	90	52	56	40 & 43
23	47 m. E. of Cape Ann,	42 52	69 35	Mud,	118	54	57	39
24	E. of Jeffrey's Ledge,	42 56	70 09	Soft mud,	114	59	57	39
24a	6 m. farther west,	----	---	--------	114	58	58	36·5 & 40
25	3½ m. S.E. from Half-way Rock,	----	---	--------	29	--	54	43·5
26	Salem Harbor,	----	---	--------	6	--	--	
27	Jeffrey's Ledge, 6 miles east of Thatcher's Island Light,	----	---	Gravel & st's,	24	57	58	46
28	8 m. E. by N. of Thatcher's Island Light,	----	---	" "	26	57	58	48
29	14 m. N.E. by E. ½ E. from Thatcher's Island Light,	----	---	" "	33	70	54	46 & 49
30	Massachusetts Bay,	42 26	70 35	Soft mud,	50	60	58	42 & 45
31	" "	42 19	70 29	Mud,	56	62	60	41·5 & 44
32	Stellwagen's Bank,	42 19	70 23	Hard, rocky,	29	64	58	48·5 & 50·5
33	" "	42 20	70 18	" "	22	64	--	48·5 & 50·5
34	" "	42 22	70 11	Sand,	44½	61	--	41·5 & 44
35	" "	42 08	70 15	"	34	59	57	48 & 50
36	20 m. E. from Cape Race,	42 18	69 49	Soft blue mud,	142	60	58	39 & 42
37	Off Massachusetts Bay,	42 20	70 00	" " "	117	--		

Among the Mollusks are several very interesting species, some of them new to the fauna of our coast; *Anachis Haliæeti* (Jeff. sp.) occurred in 114 fathoms (loc. 24), but was found in greater numbers on Cashe's Ledge (loc. 21), where several fine specimens were dredged; *Siphonodentalium vitreum* occurred sparingly at several localities in 60 to 107 fathoms; *Lasæa rubra* was only once met with (loc. 36), in 142 fathoms; *Crenella decussata* was less frequent than in our dredgings off Casco Bay; *Dacrydium vitreum* occurred sparingly several times in 60 to 142 fathoms (loc. 12, 9, 36), and also in our dredgings off Casco Bay, in 95 fathoms. These five shells are all new additions made this season to the fauna of the United States, and the *Anachis* and *Lasæa* have not been found previously on this side of the Atlantic, so far as known to me: the others have recently been dredged in the Gulf of St. Lawrence by Mr. Whiteaves.

Among the Tunicates were several fine specimens of *Glandula fibrosa* Stimpson, and also an apparently undescribed species of *Ascidia** (fig. 2), remarkable for its soft and rather flabby integument. Both these species occurred also in our dredgings off Casco Bay; the latter in great abundance in several localities, attached to scattered boulders.

2.



Among the Echinoderms there are several interesting Holothurians: the rare *Stereoderma unisemita* occurred in 142 fathoms (loc. 36); several large specimens of *Molpadia oölitica* were obtained in 95 fathoms (loc. 20); and one specimen of *Oligotrochus vitreus* Sars occurred in 60 and 105 fathoms (loc. 12 and 13). The last named species had been known before only from the deep

* *Ascidia mollis* Verrill, sp. nov. Figure 1.
Body large, hemispherical or subglobular, attached obliquely by the left side; integument rather thin, soft, and somewhat translucent, with the surface nearly smooth, but more or less wrinkled. Color, pale olive-green. Branchial aperture near one end, large, slightly elevated, surrounded by eight obtusely rounded lobes; anal orifice placed to one side of the middle of the body, little elevated, relatively small, rounded in ordinary expansion. Diameter of body usually one to two inches.

Common in 48 to 107 fathoms, attached to boulders in many localities off Casco Bay, off Manheigan I., at Jeffrey's Bank, Cashe's Ledge, etc.

waters off the Norwegian coast. It is remarkable for the beautiful and complex wheel-shaped plates scattered in its integument.

Schizaster fragilis was dredged at various localities, and is a common and characteristic species of these muddy bottoms; *Archaster arcticus* did not occur this season on the muddy bottoms, but several good specimens were obtained in 52 to 90 fathoms, on hard bottoms, near Cashe's Ledge (loc. 21), in company with *A. Parelii*, *Hippasteria phrygiana*, and other interesting species. *Ctenodiscus crispatus* was everywhere abundant. Several large and fine specimens of a peculiar Ophiuran, new to the American coast, were dredged in 142 and 117 fathoms (loc. 36 and 37). It agrees well with *Amphiura Otteri* Ljungman, which was dredged in 550 fathoms off the coast of Portugal by the Josephine Expedition. The *Ophioscolex glacialis*, from loc. 10, and *Amphipholis tenuispina*, from 105 fathoms (loc. 13), are other additions to our fauna. The former was also dredged in the Gulf of St. Lawrence last summer by Mr. Whiteaves. The *Antedon Sarsii* is a handsome comatula, new to the American coast. It was obtained at localities 6 and 21. One specimen of a cup-coral, apparently identical with *Deltocyathus Agassizii* Pourtales, previously known only from the deep water off Florida, was dredged in 142 fathoms (loc. 36). The *Ulocyathus arcticus* Sars was dredged in 150 fathoms, near St. George's Bank, by Dr. Packard, in 1872. These two species are the only stony corals yet found on the northern coast of New England; but a third species, a true *Flabellum*, of large size, has been dredged in the deeper part of the Gulf of St. Lawrence by Mr. Whiteaves.

Numerous interesting sponges occurred, which have not been identified. The curious *Hyalonema longissimum* G. O. Sars was dredged both by Dr. Packard and myself at several localities and in considerable numbers. With it an allied species often occurred, consisting of small irregular, elongated, fusiform, compact, white sponge-masses, connected by capillary stolon-like stems, made up of slender spicules twisted together. This species creeps over the bottom, but does not stand erect, like the former.

List of Species from the Gulf of Maine, inhabiting muddy bottoms, in 60 to 150 fathoms.

In the following list the species with an asterisk (*) prefixed belong more properly to the hard bottoms, but occur more or less frequently on the muddy bottoms, adhering to scattered stones, or among broken shells. Those with a dagger (†) were not obtained by Dr. Packard this season, but were mostly dredged in 1872, in the mouth of the Bay of Fundy, or near St. George's Bank; or else off Casco Bay during the past season.

The figures affixed to the names give, in fathoms, the greatest depths at which the species have been dredged on the New England Coast.

ARTICULATA.

Pycnogonida.

Nymphon giganteum, 82.
*N. grossipes (?), 65.

Crustacea.

Geryon, sp., 142.
†Chionocœtes, sp.
*Hyas araneus, 72.
*H. coarctatus, 150.
*Eupagurus pubescens, 150.
*E. Kroyeri, 430.
*E. Bernhardus, 150.
*Hippolyte spina, 72.
*H. Fabricii, 64.
Pandalus borealis, 68, 114.
*P. annulicornis, 430.
†Sabinea septemcarinata, 68.
†Caridion Gordoni, 52, 110.
Thysanopoda, large sp., 142, 430.
T. neglecta?, 105.
Pseudomma, sp., 105.
Mysis, sp., 68.
Diastylis quadrispinosa, 68.
†Praniza cerina, 68.
Asellodes alta, 90.
†Æga psora, 150.
†Conilera polita, 150.
Anthura brachiata, 110.
*Paramphithoë pulchella, 142.
Harpina fusiformis, 110.
Stegocephalus ampulla, 72, 110.
Epimeria cornigera, 106.
*Melita dentata, 430.
Melita, sp.
Haploops, sp., 105, 114.
Ampelisca, sp., 142.
Ptilocheirus pinguis, 150.
*Unciola irrorata, 430.
†Dulichia, sp., 60.
*Caprella, sp. with spines, 142.
*Scalpellum Stroëmi Sars, 90, 142, 430.
*Balanus porcatus, 150.

Annelida.

Aphrodita aculeata, 72, 90.
Lætmonice filicornis ?, 150.
*Eunoa Œrstedii, 72.
*Harmothoë imbricata, 64.
Nychia Amondseni, 106.
†Antinoë Sarsii, 110.
Enipo gracilis V., 80.
†Pholoë minuta, 68.
Leanira tetragona, 107.
Nephthys ingens, 142.
N. ciliata, 114.
Phyllodoce, sp., 110.
*P. Grœnlandica, 90.
Eteone depressa, 110.
*Nereis pelagica, 142.
Nereis, sp. 68.
†Gattiola, sp. 68, 90.
*Leodice vivida, 430.
Nothria opalina, 150.
*N. conchylega, 430.
Ninoë nigripes, 114.
Lumbriconereis fragilis, 430.
Goniada maculata, 150.
Rhynchobolus albus, 110.
†Eumenia crassa, 110.
Scalibregma inflatum, 150.
*Travisia, sp., 95, 106.
Brada, sp., 90.
Tecturella flaccida, 90.
Trophonia aspera, 150.
Ophelia, sp., 107.
Ammotrypane fimbriata, 114.
Sternaspis fossor, 142.
†Scolecolepis cirrata, 150.
†Anthostoma acutum V., 64.
Chætozone setosa, 106.
†* Dodecacerea concharum, 90.
Maldane Sarsii, 150
Praxilla gracilis, 114.
P. prætermissa, 114.
*Nicomache lumbricalis, 110.
Ammochares, sp., 142.
†Notomastus latericeus, 110.
Arenia, sp. in capillary tubes, 117.
*Cistenides granulatus, 90.
Ampharete gracilis, 106.
†A. Finmarchica, 110.
Amphicteis Gunneri, 110.
Amage auricula, 150.
Samytha sexcirrata, 110.
Melinna cristata, 150.
†Samythella elongata V., 110.
Terebellides Stroëmi, 142.
Pista cristata, 150.
Grymæa spiralis V., 95.
*Thelepus cincinnatus, 142.
*Amphitrite cirrata, 95.
†A. Johnstoni, 64.
†A. Grœnlandica, 68.
Polycirrus, sp., 110.

*Potamilla oculifera, 90.
Sabella zonalis, 107.
Chone, sp., 95.
Euchone, sp., 106.
Myxicola Steenstrupii, 72.
*Protula media, 90.
*Vermilia serrula, 106.
*Spirorbis lucidus, 114.
†Ichthyobdella, (on Raia lævis) 68.

Gephyrea.

*Phascolosoma boreale (?), 64, 90.
P. cæmentarium, 430.
P. tubicola, 110.
Priapulus, sp., 60.
Chætoderma nitidulum, 110.
†Thalassema, sp., 90.

Turbellaria.

Nemertes affinis, 110.
Meckelia lurida V., 110.
†Macronemertes gigantea V., 68.
†Ophionemertes agilis V., 90.

MOLLUSCA.

Cephalopoda.

†Octopus Bairdii V., 106.

Gastropoda.

†Pleurotomella Packardii V., 110.
Bela decussata, 64.
B. cancellata, 430.
B. pleurotomaria, 107.
B. turricula, 117.
Admete viridula, 150.
Neptunea curta, 68.
N. decemcostata, 107.
Neptunella pygmæa, 430.
Buccinum undatum, 52.
*Anachis Haliæeti, 114.
†Ringicula nitida V., 110, 150.
Natica clausa, 430.
Lunatia Grœnlandica, 430.
L. immaculata, 430.
*Torellia vestita, 90, 150.
*Trichotropis borealis, 80.
*Velutina zonata, 150.
*V. lævigata, 110.
Aporrhais occidentalis, 150.
Turritella erosa, 106.
Scalaria Grœnlandica, 85.
Rissoa exarata, 95.
*Margarita obscura, 430.
*M. cinerea, 150.
*Calliostoma occidentale, 82.
*Diadora noachina, 430.
*Lepeta cæca, 110.
Scaphander puncto-striata, 150.
Cylichna alba, 150.
Utriculus pertenuis, 114.
Philine quadrata, 110.
P. lineolata, 64.
*Doris planulata, 142.
*Trachydermon albus, 150.
†Stimpsoniella Emersonii, 60.
†*Hanleia mendicaria, 80.
Dentalium occidentale, 150.
Entalis striolata, 150.
†E. agilis ?, 95.
Siphonodentalium vitreum, 107.

Lamellibranchiata.

†*Zirphæa crispata, 80.
Mya arenaria (young), 64.
Neæra arctica, 150.
N. pellucida, 142.
*Saxicava arctica, 114.
Panopæa Norvegica, 114, 118.
Thracia myopsis, 150.
T. truncata.
Periploma papyracea, 109.
Macoma sabulosa, 142.
Cyprina Islandica, 72.
Cardium pinnulatum, 150.
C. Islandicum, 117.
Cryptodon Gouldii, 110.
C. obesus, 430.
Lucina filosa, 142.
Lasæa rubra, 142.
Astarte lens, 430.
A. undata, 117.
A. quadrans, 150.
Cyclocardia borealis, 107.
C. Novangliæ, 90.
Nucula tenuis, 142.
N. proxima, 60.
N. delphinodonta, 68.
Leda tenuisulcata, 150.
Yoldia obesa, 150.
Y. thraciformis, 142.
Y. sapotilla, 117.
*Arca pectunculoides, 150.
*Modiolaria nigra, 107.
*M. discors, 90.
M. corrugata, 105.
Crenella glandula, 110.
C. decussata, 60.
Dacrydium vitreum, 95, 107, 142.
*Pecten Islandicus, 114.
†P. pustulosus, 430.
*P. tenuicostatus, 110.
*Anomia aculeata, 150.

Tunicata.

*Ascidia mollis V., 107.
*Ascidiopsis complanatus, 110.
*Ciona tenella, 64.
Molgula pannosa.
*M. retortiformis, 68.
Eugyra pilularis, 105, 114.
Glandula fibrosa, 95, 106.
*G. arenicola, 150.
*Cynthia echinata, 64, 80.
*C. carnea, 64, 80.
*Botryllus, sp., 64.
*Amarœcium glabrum, 64.
*Leptoclinum albidum, 72.

Brachiopoda.

*Terebratulina septentrionalis, 150.

Polyzoa.

*Crisia eburnea, 117.
*Hornera lichenoides, 150.
*†Discoporella verrucaria, 150.
*Idmonea pruinosa, 118.
*Discofascigera lucernaria, 110.
*Flustra solida St., 64.
*Membranipora pilosa, 64.
Gemellaria loricata, 142.
*Cellularia ternata, 150.
*C. scabra, 95.
C. Peachii (?), 150.
Bugula, soft sp., 95, 430.
*B. fastigiata, 150.
Bugula Murrayana, 430.
Caberea Ellisii, 150.
*†Anarthropora borealis, 150.
*Cellepora scabra, 150.
*C. ramulosa, var., 150.
*†Alcyonidium, sp., 64.

RADIATA.

Echinodermata.

*†Lophothuria Fabricii, 110.
*Psolus phantapus, 72.
†*Pentacta assimilis, 95, 430.
†Thyone scabra V., 110, 150.
Stereoderma unisemita, 142.
*†Thyonidium productum, 80.
Molpadia oölitica, 95.
Oligotrochus vitreus, 105.
Schizaster fragilis, 430.
*Echinarachnius parma, 430.
*Strongylocentrotus Dröbachiensis, 430
*Leptasterias compta, 90.
*L. tenera, 65, 142.
†Solaster furcifer, 150.
*Cribrella sanguinolenta, 90.
*Hippasteria phrygiana, 60, 90.
*†Archaster arcticus, 90, 150.
Ctenodiscus crispatus, 114.
Ophioglypha Sarsii, 430.
O. robusta, 118.
O. affinis, 105, 118, 150.
Amphiura Otteri, 117, 142.
*Amphipholis elegans, 105.
A. tenuispina, 105.
*Ophiopholis aculeata, 104.
Ophiacantha spinulosa, 150.
Ophioscolex glacialis, 104.
†*Astrophyton Agassizii, 90.
*Antedon Sarsii, 82.

Acalephæ.

†*Campanularia verticillata, 430.
†*Calycella producta G. O. Sars, 430.
C. plicatilis (Sars sp.), 97.
*Sertularia cupressina, 150.
*Sertularella polyzonias, robust var., 142.
†*S. geniculata Hincks, 430.
*S. tricuspidata, 430.
*Lafoëa gracillima, 430.
†*Halecium robustum V., 430
*Eudendrium ramosum, 430.
*Tubularia indivisa, 430.
Corymorpha pendula, 95.

Anthozoa.

†Virgularia Lyungmanii, 150.
†Pennatula aculeata, 110, 150.
†*Cornulariella modesta V., 106.
*Urticina nodosa (Fab. sp.), 430.
*U. crassicornis, 430.
*Bolocera Tuediæ, 150.
Edwardsia farinacea V., 95.
E. sipunculoides, 106.
†Ilyanthus levis V., 60.
Cerianthus borealis V., 150.
†*Epizoanthus Americanus, 430.
Deltocyathus Agassizii, 142.
†Ulocyathus arcticus, 150.

Spongiæ.

Hyalonema longissimum, 95.
*Polymastia, sp., 117.
*†Phakerellia ventilabrum, 68.
*Reniera, soft sp., etc.

EXPLANATION OF PLATES.

Plate IV.—Figure 1, *Nothria opalina* V.; head and anterior part of body.
Figure 2, *Lumbriconereis fragilis;* head and anterior part of body.
Figure 3, *Ninoë nigripes* V.; one of the appendages from the middle part of body.
Figure 4, *Nephthys ciliata;* one of the appendages.
Figure 5, *Phyllodoce catenula* V.; head, anterior part of body, and proboscis.
Figure 6, *Stephanosyllis picta* V.; head, anterior part of body, and caudal segments.

Plate V.—Figure 1, *Procerea gracilis* V.; head and anterior part of body.
Figure 2, *Eulalia pistacia* V.; anterior and posterior portions.
Figure 3, *Pista cristata* M.; head and anterior part of body.
Figure 4, *Grymæa spiralis* V.; head and anterior part of body.

All the figures were drawn from nature by Mr. J. H. Emerton, except fig. 4, plate IV, which was copied from Ehlers; all are much enlarged.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Variations of Chemical Activity in the Solar Spectrum and on an Apparatus for their measurement.*—In his spectro-photographic researches, VOGEL has sought to determine, not only the absorbing action of various colored media, but also the chemical action exerted by the sun-spectrum upon pure silver bromide. Finding it impossible to get correspondent results, even under apparently identical conditions, he was at first led to attribute the variations to differences of delicacy in the plates employed. Sometimes the action extended more into the violet or ultra-violet, sometimes more into the yellow and red. Exact experiments with different plates, exposed at the same time in a camera having two similar objectives, proved these variations in delicacy to be insignificant in comparison with the results; and hence proved that changes took place in the relative intensity of the spectrum colors themselves. Now it is well-known that, as the sun nears the horizon, the luminous intensity of the violet diminishes much more rapidly than that of the red. Bunsen and Roscoe have proved that the chemical activity of the spectrum rays also varies, since these are absorbed differently by the atmosphere at different periods of the day. But precisely what these variations are throughout the whole spectrum, it has been reserved for the silver-bromide plate to show. Vogel gives the results of his experiments in a table in which the day (and time of day), the sun's height, the time of exposure and the state of the barometer and psychrometer, are given. On the 7th of October, at 2 P. M. the photographic activity of the spectrum extended from a point midway between C and D to considerably beyond H. On the 17th, at 2.30, it reached from a point short of D to a point nearly to H′. On the 18th, from a point midway between C and D, to a point considerably short of H. On the 29th, from beyond B to a

point two-thirds of the distance from G to H. And on the 30th its extent was about the same as on the 7th. On these days the sun's altitude at the time of exposure varied from 20° to 26° only; the time of exposure from 7′ to 10′; the barometric height from 335 to 339 lines; and the vapor-tension 2 to 5 lines. On Dec. 7th an observation with the sun 15° high at 11h. 16½m. A. M., showed the spectrum to reach less far into the red and farther into the violet than a second observation at 2h. 3½m. P. M., with the sun 11° 14′ high; though the former of these two spectra extended nearly as far into the violet as the spectrum of the 7th of October when the sun was 26° high. In general, when the action increases toward the violet, it decreases toward the red, and vice versa. As to the cause of the action, Vogel considers the observations yet too incomplete to lead to any conclusions, though from the rapidity with which they occur, he thinks they cannot have their origin in the sun. He calls attention to the want of sensitiveness of silver-bromide for the violet rays, and says the limits given are those for which silver-bromide is sensitive. By using a wedge-like slit to form the spectrum, and exposing to this spectrum a silver-bromide plate, the horizontal extension of the image will indicate the activity of the red and violet; while the vertical extent of the action will be directly proportional to the intensity of the various colors. The author promises some results with such an apparatus.—*Ber. Berl. Chem. Ges.*, vii, 88, Feb., 1874. G. F. B.

2. *On Plateau's Glyceric liquid, and some new Film experiments therewith.*—The difficulty of preparing Plateau's glyceric liquid by either of the methods given by Plateau himself, has led M. Terquem to propose a method founded on the solubility of the oleates in alcohol. Finely divided Marseilles soap is thoroughly dried and placed in a flask with 80 per cent alcohol (sp. gr. 0·865), which is allowed to act upon it cold. A mixture of glycerin and water is then made of such strength that it has a density of 1·35 at 20° (17°·1 B.), and heated to the temperature of boiling water to destroy the germs and spores it may contain. To 100 c.c. of the diluted glycerin, 25 c.c. of the alcoholic soap solution is added, and the whole is heated till its boiling point rises above 100°, to drive off the alcohol. After cooling it is poured into a graduated cylinder, and its volume brought to 100 c.c. by the addition of distilled water. It is filtered through a plug of cotton placed in the funnel. With the clear liquid thus made, a bubble a decimeter in diameter placed on a tripod will remain, if covered with a bell jar, more than an hour.* For illustrating the colors of thin films, a copper ring—made of wire 5 mm. thick—fifteen centimeters in diameter is used, which is mounted vertically on a stand and can be covered with a bell-glass. A portion of the liquid being poured into a plate, the ring is laid flat upon its surface, and on removal a film of the liquid will adhere to it. Covering the ring with a

* A liquid easier to prepare, but not giving as thin films, is made as follows: 1 gram dry Marseilles soap is dissolved in 100 grams warm water; this is filtered, and to every 100 c.c. of the solution, 40 grams white sugar is added. Bubbles made with this liquid will last several hours.

gutta-percha varnish facilitates this adherence. On throwing diffuse light on the film and viewing it at an angle of 45°, beautiful bands of color are observed, first of a high order, then successively lower, until in one-half or three-quarters of an hour it gives the uniform yellow of the first order. Then a segment completely black appears, and shortly after the film breaks. By refraction the colors are quite as brilliant, but of course are complementary. Both sets may be projected on a screen at once; the transmitted colors, by focussing the inclined film, illuminated with a beam of sunlight, directly on the screen by means of an achromatic lens; the reflected colors, by receiving the reflected beam from the film on an achromatic lens in the principal focus of which is a plane mirror reflecting the image on to the same screen. The colors are as brilliant as those given by selenite films in polarized light. By allowing the sunlight to enter through a slit, which is in one conjugate focus of a lens having the film in the other, and placing a prism close behind the lens so as to throw a spectrum upon this film at a small angle with its surface, the light reflected from this surface being brought to a focus on the screen by means of a lens, the image appears curiously furrowed with inclined black bands. By simply turning a prism so as to illuminate the film with light of different colors, these black bands will be seen to approach or recede from each other according as the red or the violet end of the spectrum falls on the film. By reflecting the solar light from the slit directly on to the lens, then allowing it to pass through a prism and to be reflected on to the screen by a plane mirror, the spectrum of the reflected beam is obtained, showing inclined dark bands across its breadth.—*J. de Physique*, ii, 409, Dec., 1873.

G. F. B.

3. *On the Preparation of Nitric Oxide*, N_2O_5.—BERTHELOT has recently published an improved process for obtaining readily this oxide. He proceeds as follows: monohydrated nitric acid, cooled by a freezing mixture, is mixed with pulverulent phosphoric oxide in small portions at a time, taking care to avoid any elevation of temperature. The temperature of the mass should never exceed 0°. When a little more than its weight of phosphoric oxide has been added to the nitric acid, the mass becomes of the consistence of a jelly. It is then placed in a roomy tubulated retort, and distilled with extreme slowness. The products are condensed in receivers with ground stoppers, immersed in ice. In this way large brilliant colorless crystals of nitric oxide (N_2O_5) are obtained, which are perfectly pure. From 150 grams of nitric acid, nearly 80 grams of the crystals were obtained. This substance is non-explosive, either as a solid or in vapor. It decomposes, however, very easily, and this at the ordinary temperature, as Deville has observed, into nitrogen tetroxide and oxygen. It should not be preserved in hermetically sealed vessels. It keeps well in good glass stoppered bottles placed under a bell-glass with sulphuric acid. In the air the crystals evaporate slowly, evolving abundant vapors, but not liquefying. Hence they can be weighed

without difficulty. Light accelerates its decomposition; as does also heat, though even at 43° it is not very rapid. This change into nitrogen tetroxide and oxide is endothermic, and is not reversible.—*Bull. Soc. Ch.*, II, xx, 53, Jan., 1874. G. F. B.

4. *On Ammonium nitrite.*—This salt is rarely seen in the dry form, and hence has been but little studied. BERTHELOT, having occasion to prepare it for his thermochemical researches, gives the following account of it: It was prepared by decomposing pure barium nitrite by ammonium sulphate in exactly equivalent proportions, in the cold. The filtered liquid was evaporated in vacuo, over caustic lime, at ordinary temperatures. The operation lasted several weeks, and, owing to decomposition even then, the yield was only 30 to 40 per cent of that required by theory. It is necessary to evaporate to complete dryness, and to preserve the solid salt in vacuo, over caustic lime. The mass is white, crystalline, somewhat elastic and tenacious, so that it may be moulded between the fingers, and adheres to the walls of the containing vessel. It is perfectly neutral and corresponds to the formula $(NH_4)NO_2$. It is very deliquescent. At the ordinary winter temperature, it decomposes very slowly; at that of summer, more rapidly. Heated to 60° or 70° on the water-bath, it detonates violently after a few seconds. It detonates also by a blow from a hammer. Its decomposition disengages almost as much heat as nitroglycerin; hence its activity. It cannot be kept in sealed tubes, because they soon explode from the pressure of the gases generated. It is best kept as above. Aqueous concentrated solutions decompose more rapidly than the dry salt, in the cold; so that when agitated they evolve gas like champagne. Ammonium nitrite may be formed synthetically by mixing together nitrogen dioxide, ammonia and oxygen. The solid nitrite condenses on the walls of the tube in crystalline masses apparently cubical in form; and this is an instructive lecture experiment.—*Bull. Soc. Ch.*, II, xx, 55, Jan., 1874. G. F. B.

5. *Mechanical Equivalent of Heat.*—H. SERRANO Y. FATIGATI has for the first time determined the relation which subsists between the work expended to turn the disk of a Ramsden electrical machine and the electro-static decompositions produced. The following are, in brief, the processes employed, and the results attained.

To turn the disk and measure the work, he wound round the handle of the disk of a Ramsden machine two strings passing over two pulleys, and carrying each a weight at its extremity—the one of 17 kilograms, and the other of 22. These weights descended near two graduated rules. He deducted from the calculated work, 1st, the work equivalent to the *vis viva* retained by the weights at the end of their fall, and 2nd, the work consumed by the friction of the strings against the handle and in the pulleys.

On the other hand, he estimated as exactly as possible the heat developed by the cushions; first, by employing a good mercurial thermometer, and then by means of a thermo-electric pile, compared with the preceding indications, and measuring approximately the specific heat of the cushions and the disk, taking into consideration the losses in the air. The quantity thus obtained was likewise deducted from the calculated work.

Finally, to measure the electrolization, he took two large test-tubes, graduated and furnished with platinum wires extending to their bottoms, one of which was connected with the machine, while the other was in communication with the earth. These tubes were immersed in a large reservoir containing acidulated water, and united by means of a long string wetted, to serve as a conductor to the electricity without producing sparks.

The results of twenty-eight observations are given in the following table, in which the first column gives the number of experiments, the second the amount of hydrogen disengaged in milligrams, the third the calories of dissociation, the fourth the work in kilogrammeters and the fifth the mechanical equivalent found.

No. Ex.	H.	Calories.	Work.	M. Equiv.
12	17	0·578	272·84	471·99
7	42	1·428	649·74	455.00
9	5	0·170	79·5	467·64

The mean of these results gives for the mechanical equivalent of heat the number 464·87.—*Bib. Univ.*, 252, 1873, *Phil. Mag.*, 155, xlvii. E. C. P.

6. *Distribution of magnetism in soft iron.*—Jamin has recently conducted a series of experiments on the distribution of the magnetism in a square bar of soft iron, two meters long and twenty millimeters on a side. Its ends were surrounded with coils of wire, through one or both of which a current from twenty Bunsen cells could be passed.

When one coil only was used, the magnetism at a distance x was expressed by the quantity $\frac{A}{a^x}$, in which $A = 11·95$ and $a =$ 1·161 in this particular case. In other words, the distances being taken in an arithmetical progression, the magnetism would diminish geometrically. If the length of the bar was not indefinitely great, the effect produced was the same as if the curve representing the distribution of the magnetism was reflected, and the ordinates thus obtained added to those of the first curve.

If now both coils were employed and the currents sent in the same direction, the reflected portion of one neutralized that of the other. But if sent in opposite directions, so that both ends of the bar should be north or both south, the reflected portions added, and the total attracting power of the bar was increased by this amount. This result seems to be quite at variance with Ampère's theory of magnetism. All these conclusions are sustained by series of observations which show a remarkable agreement with theory.—*Comptes Rendus*, lxxviii, 95. E. C. P.

7. *Electro-torsion.*—Mr. George Gore presented to the Royal Society, at a recent meeting, a communication on the twisting of

iron rods whilst under the influence of electric currents. This effect is by no means a microscopic one, but may be made to exceed, in some cases, a twist of a quarter of a circle, the end of a suitable index moving through a space of eighty centimeters. It is always attended by emission of sound.

The torsions are produced by the combined influence of helical and axial currents, one current passing through a long copper-wire coil surrounding the bar or wire, and the other in an axial direction through the iron itself. The cause of them is the combined influence of magnetism in the ordinary longitudinal direction, induced in the bar by the coil current, and transverse magnetism induced in it by the axial one.

The torsions are remarkably symmetrical, and are as definitely related in direction to the electric currents as magnetism itself. The chief law of them is, a current flowing from a north to a south pole produces left-handed torsion, and a reverse one, right-handed torsion, i. e., in the direction of an ordinary screw. Although each current alone will produce its own magnetic effect, sound, and internal molecular movement, neither alone will twist the bar, unless the latter has been previously magnetized by the other. Successive coil-currents alone will not produce torsion, neither will successive and opposite axial ones.

Signs of electro-torsion were obtained with a bar of nickel, but not with wires of platinum, silver, copper, lead, tin, cadmium, zinc, magnesium, aluminum, brass or German silver, or with a thick rod of zinc, or a cord of gutta-percha.—*Nature*, Jan. 19th.

E. C. P.

8. *Physiology of Flight.*—M. Marey, having in a previous paper shown the path described by the wing of a bird and its effect on the motion of the animal, now describes some experiments with artificial wings with which he attempts to raise bodies of greater or less weight. That the apparatus may raise itself, it is necessary that the moment of the moving force shall be a little greater than that of the resistance of the air, and that the magnitude of this resistance shall be for each wing one half the weight of the mass to be raised. If we suppose the wing triangular and the resistance of the air proportional to the square of the velocity, the point of application of the resultant will be on the line bisecting the wing at $\frac{3}{5}$ths of the distance from the joint to the tip. To assure himself that these conditions were fulfilled in nature, he measured the statical effort of which the pectoral muscles were capable, their point of insertion, the form of the wings, and the weight of the body of various birds. He then constructed a mechanical arrangement by which the natural movements might be imitated. But on comparing the velocities required with those obtained from registering the motion of the wings of real birds, he found that, to raise itself, the wings of the machine should have a velocity three to four times that of the wings of the bird. Or, that in the latter case the resistance of the air seemed to be from nine to sixteen times that in the former. The more he repeated

these experiments the more convinced he became that the resistance of the air under the wings of birds would not be sufficient to sustain them, if it was not increased by some condition wanting in the mechanical device. This condition he claims is found in the increased resistance due to the motion of translation of the bird.

Air, like all movable bodies, possesses inertia, so that when acted on by a force it at first resists strongly, then acquires a velocity, and tends to preserve it after the original force ceases to act. The resistance of the air to a body moving uniformly may therefore be divided into a constant condition, preceded and followed by a variable condition, produced when the body starts or stops; the pressure in the first case being greater, and in the latter less, than the normal. Admitting then that the resistance of the air attains its maximum when the body starts, it is clear that the wing of a bird ought to find a more solid support in the air, if throughout its whole stroke it can place itself in this condition. But in consequence of the motion of translation of the bird, the wing is continually acting on a new portion of the air, which, on account of its rapid motion, has no time to acquire its velocity. It is therefore compressed and offers its maximum resistance.

To prove the correctness of this theory, it was necessary to impart a horizontal velocity to the artificial bird, and to see if there was any increased resistance to the motion of the wings. A little steam-engine working uniformly, put in motion an air-pump, which in turn moved the wings regularly. The machine was placed at the end of a long arm free to revolve, so that while in action it could receive a rapid motion in a large circle. Under these conditions he found that when at rest the wings moved through an angle of 60°, but when moving with a velocity of ten meters per second, the angle was reduced to 30°, or even 20°, while employing the same power. Fearing that centrifugal force might interfere with the results, the experiment was repeated, giving a rectilinear motion to the machine, and a similar effect was observed.

Many familiar facts are thus easily explained. Thus, when a bird rises, the extent of motion of the wings is much greater than when it has acquired a large horizontal velocity. When attached to a cord it falls, notwithstanding its flapping, as soon as the tension arrests its horizontal motion. When a bird is suspended from a bar which is caused to revolve so that it shall fly in a circle, and a rapid motion is imparted to it, the strokes of the wing take place very slowly, sometimes only once a second in the case of a pigeon, instead of eight times a second, which is their normal rapidity.—*Comptes Rendus*, 121. E. C. P.

9. *The Vermiculites: their Crystallographic and Chemical relations to the Micas, together with a discussion of the cause of the variation of the optical angle in these minerals*; by JOSIAH P. COOKE, Jr.*—*Introduction.*—In the American Journal of Science (vii, 55, 1824), T. H. Webb described a mineral from Millbury, near Worcester, Mass., which has since been a mineralogical

* Abstract of a paper published in the Proceedings of the American Academy of Arts and Sciences, vol. ix, page 35; prepared for this Journal by the author.

curiosity on account of its singular reaction when heated. The mineral consists of "small foliated scales distributed through a steatitic base." When heated, it exfoliates prodigiously, the scales opening out into long worm-like threads made up of the separate foliæ. Exfoliation commences at 500° to 600° Fahr., and takes place with so much force as often to break the test-tube in which the mineral may be confined. Before the blowpipe it fuses at 3·5 to a grayish-black glass." It was named by Webb, as he says, "from the Latin *vermiculor*, 'I breed worms.'" The hardness of the mineral is 1–2, the specific gravity 2·756, the luster talcose, and the color grayish, somewhat brownish. It was analyzed by Crossley, who "separated with great care from the base the scaly mineral, which is the true vermiculite," and his results were as follows:—

	1.		Oxygen Ratio. True.	App.	2.		Oxygen Ratio. True.	App.
Silica	35·74	19·06	19·06	11	35·74	19·06	19·06	2
Alumina	16·42	7·65	7·65	4	16·42	7·65		
Ferric oxide					11·13	3·34	10·99	1
Ferrous oxide	10·02	2·23						
Magnesia	27·44	10·98	13·21	7	27·44	10·98	10 98	1
Water	10·30	9·16	9·16	5	10·30	9·16	9·16	1
	99·92				101·03			

The results of analysis in column 1, and the portions of the description of the mineral in quotation-marks, above, have been taken from "Dana's System of Mineralogy," fifth edition, page 493; and the atomic ratio which is there deduced is,

$$\overset{\text{IV}}{Si} : \overset{\text{VI}}{\mathbf{R}} : \overset{\text{II}}{R} : \overset{\text{II}}{\mathbf{H}} = 11 : 4 : 7 : 5.$$

In this analysis, however, Crossley could not have determined the state of the iron, which, in the specimen I have examined, is almost wholly in the ferric condition. If now we assume that the whole of the iron belongs with the sesquioxide radicals, the analysis would appear as in column 2, and the atomic ratio is then seen to be 2 : 1 : 1 : 1, which is undoubtedly the correct result.

In the year 1851, Mr. W. W. Jefferis, of West Chester, Pa., discovered at the ripidolite locality near that town a peculiar micaceous mineral which exfoliates like the Millbury vermiculite, but which, instead of occurring in small foliæ, is found in large hexagonal plates. This mineral was analyzed by Professor Brush; and although at first referred by him, "with a query," to vermiculite (this Jour., II, xxxi, 369, 1861), was subsequently described as a new species (this Jour., II, xli, 248, 1866), and named Jefferisite.

Several years later, Mr. John Hall, now of Philadelphia, sent to me for examination some rough six-sided prisms of a micaceous mineral, which he had discovered at East Nottingham, in Chester County, Pa. This mineral also exfoliates when heated. It is a new species, and I have named it, after the discoverer, Hallite.

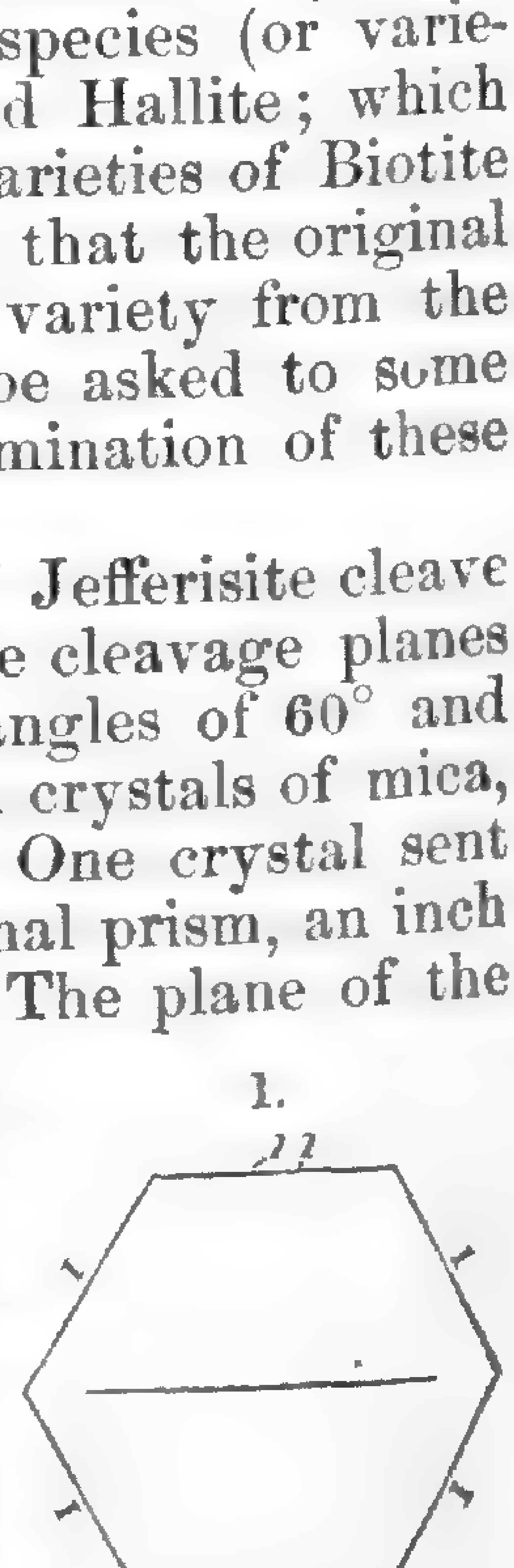
A year since I received from Colonel C. W. Jenks, in connection with other minerals from his corundum mine on the Culsagee river, in Macon County, N. C., a specimen of still another micaceous mineral having the same remarkable pyrognostic properties. It proved to be the best defined of any of this class of minerals which I had examined, and I shall designate it as Culsageeite.

Besides the above, there have been found several other micaceous minerals whose pyrognostic and crystallographic characters indicate that they belong to the same family, but which have not yet been investigated.

The remarkable exfoliation and great apparent increase of volume which the class of minerals under consideration undergo when heated are analogous to the well-known phenomena presented in the dehydration of alum, borax and other crystalline salts, when heated in a similar way; and it will be one object of this paper to show that the effect is due to the same cause,—namely, to the escaping of what we call water of crystallization. I also expect to show that the several minerals referred to above are members of a family of hydrous silicates closely allied and parallel to the well-known family of anhydrous silicates called the micas, and that their molecules differ from those of the magnesian micas chiefly in containing a definite number of molecules of water; that is, water of crystallization. I shall call this family of minerals "the vermiculites," using the original name, as "mica" is now employed, to designate a class; and I shall call the three species (or varieties?) of this family Jefferisite, Culsageeite and Hallite; which correspond, as I expect to show, to the two varieties of Biotite and to Phlogopite respectively. It will appear that the original vermiculite has the same composition as the variety from the Culsagee mine. Finally, attention will also be asked to some unexpected discoveries to which the optical examination of these minerals has led.

Jefferisite, of West Chester.—The crystals of Jefferisite cleave like mica, affording thin but unelastic folia. The cleavage planes are marked triangularly by lines, crossing at angles of 60° and 120°. In some cases there is a jointing as in crystals of mica, parallel to the shorter diagonal of the rhomb. One crystal sent me by Mr. Jefferis is the half of a rough hexagonal prism, an inch and a quarter high by two inches in diameter. The plane of the optical axes, as in the larger number of micas, is parallel to one of these lines, as indicated in fig. 1, coinciding with the shorter diagonal of the rhombic prism, which appears to be the fundamental form in all this class of minerals, and from which the hexagonal form is derived by the truncation of the two acute angles. The double refraction is strongly negative, but the angle between the optical axes varies in the most remarkable manner. I have measured angles on different plates, of 27°, 24° and 10°, and observed many intermediate conditions. Owing to the deep yellow color, the plates become opaque at a very moderate thickness, and for this reason it is impossible to measure the angle with great precision.

1.



Some of the plates are apparently uniaxial; but this may result from the blending of the two hyperbolas, due to the thinness of the plate. The dispersion of the axes is but slight, and only perceptible in the thicker laminæ when $\rho < v$. It is obvious, therefore, that the crystallographic characters of the mineral are identical with those of mica.

The plates are generally, if not invariably, twinned, and the twinning is the cause of this most remarkable variation in the optical angle, as will be explained at length in connection with our description of Culsageeite. On this last mineral the same phenomena are more marked, owing chiefly to the greater transparency of the plates.

In order to illustrate the chemical relations of the mineral to the Biotite micas, we give below: 1st. The results of the analysis of Jefferisite by Prof. Brush. 2d. The same results, calculated for the anhydrous mineral. 3d. The results of an analysis of a Biotite mica, from Pargas, Finland, by Svanberg. In each case I have added the amounts of oxygen in the several oxides, to show the atomic ratios:—

	$\ddot{\mathrm{Si}}$	$\overline{\mathrm{Al}}$	$\overline{\mathrm{Fe}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{H}}$	
(1)	37·10	17·57	10·54	1·26	19·65	0·56	0·43	13·76	=100·87
	19·78	8·18	3·16	·28	7·86	·16	·07	12·23	
	19·78	11·35		8·37				13·23	
	5·	3·		2·				3·	

	$\ddot{\mathrm{Si}}$	$\overline{\mathrm{Al}}$	$\overline{\mathrm{Fe}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{K}}$	
(2)	42·94	20·33	12·20	1·46	22·75	·66	·50	=100·84
	22·90	9·47	3·66	·32	9·10	·19	·08	
	22·90	13·13		9·69				
	5·	3·		2·				

	$\ddot{\mathrm{Si}}$	$\overline{\mathrm{Al}}$	$\overline{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{H}}$	F	
(3)	42·58	21·68	10·39	·75	10·27	1·04	8·45	3·35	·51	= 99·01
	22·71	10·10	3·12	·17	4·11	·30	1·43	2·98		
	22·71	13·22		8·99						
	5·	3·		2·						

The general symbol of Jefferisite deduced from (1) would be,—

$$\overset{\mathrm{II}}{\mathrm{R}}_4,\ \overset{\mathrm{VI}}{\overline{\mathrm{R}}}_2 \,.\, \mathrm{O}_{20} \,.\, \mathrm{Si}_5 \,.\, 6\mathrm{H}_2\mathrm{O}.$$

A comparison of the results given in (2) and (3) will show that the anhydrous Jefferisite corresponds very closely in its chemical constitution with the Biotite mica from Pargas. The chief difference is to be found in the fact that the mica contains potassium and basic hydrogen, in place of more than one-half of the magnesium of the Jefferisite. It should, however, be remembered in this connection that the Biotites present a very wide variation in the ratio between the amounts of the protoxide and sesquioxide radicals which the various varieties contain. The limits usually assigned to this variation correspond to the ratios—

$$\overset{\text{II}}{R} : \overset{\text{VI}}{R} : Si = 1 : 2 : 3, \text{ and } \overset{\text{II}}{R} : \overset{\text{VI}}{R} : Si = 1 : 1 : 2,$$

and the Pargas mica with the ratio 2 : 3 : 5 falls between these limits; but the Culsagee variety of vermiculite corresponds to the more common class of Biotites, which have the ratio 1 : 1 : 2.

But this resemblance in chemical constitution only appears when we compare the Biotite mica with the anhydrous Jefferisite; while it is the crystallized hydrous Jefferisite which so closely resembles the magnesian micas in its crystallographic relations; and the question now arises, What is the condition of the large amount of water—12¼ per cent—which the crystallized mineral contains?

To aid us in forming a conclusion on this point, we have the following evidence:—

First. As the above analysis shows, the water is united in definite and atomic proportions amounting to six molecules to every five molecules of silicon in the molecules of the mineral, that is, sufficient to convert all the silicon into a hydrate, assuming that the five silicon atoms in this hydrate are joined to each other by the smallest possible number of bonds.

Secondly. While both the crystallographic and the chemical relations of Jefferisite to the other vermiculites, and to the magnesian micas, indicate that the mineral is an orthosilicate, the amount of basic radical, exclusive of the water, is amply sufficient to saturate the atomicity of the silicon.

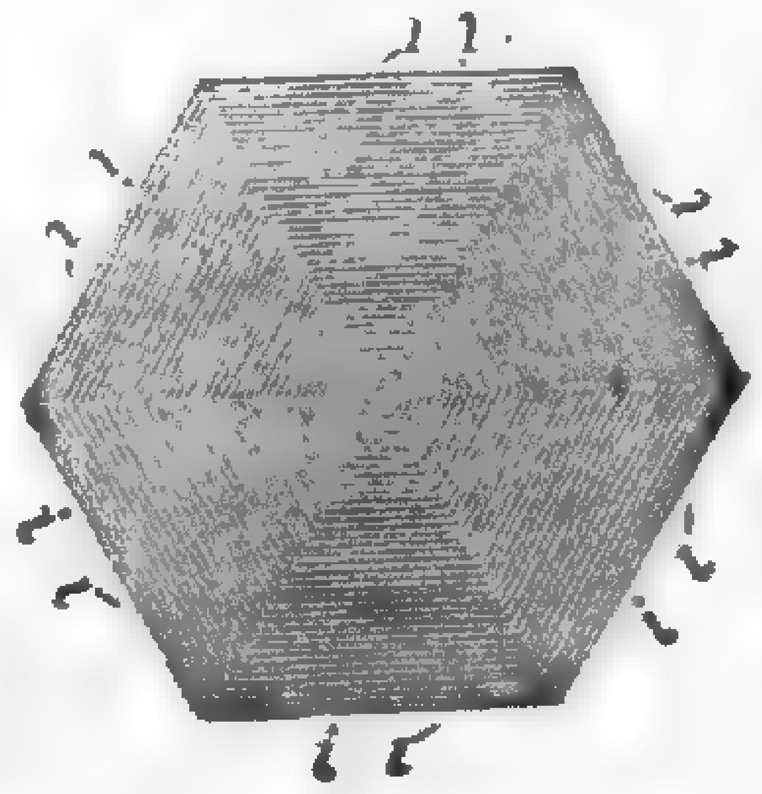
Thirdly. It was observed by Prof. Brush—and his observations have been fully confirmed by ourselves—that the water is given off at a comparatively low temperature,—about 300° C.; and, as every mineralogist knows, this dehydration is attended with that remarkable exfoliation which is characteristic of the vermiculites, and indicates a complete disintegration of the molecular structure. This exfoliation is wholly different from the phenomena which the so-called hydrous micas present under like conditions. In these last—which, as we suppose, contain hydrogen as a part of the basic radical of their molecules—a very high temperature is required to expel the water, and the loss is attended by no such marked change of volume and disintegration.

The conclusion that we draw from these facts is, that the combined water is in the same condition in Jefferisite as in the zeolites, and in many crystallized salts,—a condition which has long been known in chemistry as *water of crystallization.* We shall not here attempt to discuss what are the relations of the water thus combined to the molecular structure of the mineral. This question is still in suspense, and we are persuaded that our science is not yet in a condition to solve the problem. All that we can at present do is to classify the phenomena presented by the exfoliation of the vermiculite minerals with the efflorescence of Glauber's salt or the intumescence of alum, and our object is simply to make prominent the two points: 1st. That the crystallographic structure of Jefferisite is identical with that of the magnesian micas.

2d. That the chemical constitution of the anhydrous mineral is closely allied to that of Biotite.

Culsageeite or the Vermiculite of the Jenks Mine, North Carolina.—The vermiculite at this locality occurs in close contact with ripidolite, and is frequently interlaminated with it, *but the two are always perfectly distinct*, thus entirely disproving the theory that the vermiculite was derived from the ripidolite by weathering. It occurs in large plates having more or less of an hexagonal outline. Some of those received from Col. Jenks were five inches in diameter. It has a greenish-yellow color, which is very much lighter than that of the West Chester variety. The plates are strongly marked by lines crossing at angles of 60° and 120°, like those from West Chester; but these lines are more marked in the North Carolina variety. This variety is also much more friable than the other, and readily breaks in directions parallel to these lines,—yielding rhombic plates with angles of 120° and 60°, and more readily hexagonal or triangular plates, produced by the truncation of the 60° angle of the rhombic plate, on a line parallel to the shorter diagonal of the fundamental rhomb. The plates most readily break parallel to this diagonal, and, like the specimens from West Chester, are frequently jointed in this direction. Like other micaceous minerals, the plates cleave readily parallel to the basal plane, yielding very thin foliæ, exceedingly flexible but not elastic. The optical characters are the same as those of the West Chester variety,—strong negative double refraction yielding a biaxial ring system, with uniform distribution of colors, and very variable optical angle. I have measured angles from about 30° to about 13°. The angle often varies widely in different parts of the same plate. Thus I have measured on different laminæ, from a single plate not exceeding three inches in diameter, the three angles, 30°, 24°, and 13°; and again I have noticed a similar variation on one and the same lamina. Indeed, the phenomena which I observed were almost identical with those I had previously observed on plates of ripidolite from Texas, Pennsylvania, *loc. cit.* On moving the lamina just referred to parallel to itself, in front of the polarizing microscope, the optic angle varied as I passed from one side of the field to the other. Beginning with a value of about 30°, the angle decreased to about 13°. Moving the plate still further, I found a region of indistinctness, and then the axes opened again,—the new plane making an angle of 120° to the old. I had evidently here a macling precisely similar to that I had previously described in the Texas ripidolite, and shown in fig. 2, where the lines of shading represent the position of the plane of the optical axes. This represents what we may call an ideal macle; for I have seldom been able to trace more than three individuals on the same plate, and, as a rule, these are very unequally developed. On many of the specimens of the North Carolina vermiculite, the macling is externally marked by the eminent cleavage or jointing

2.

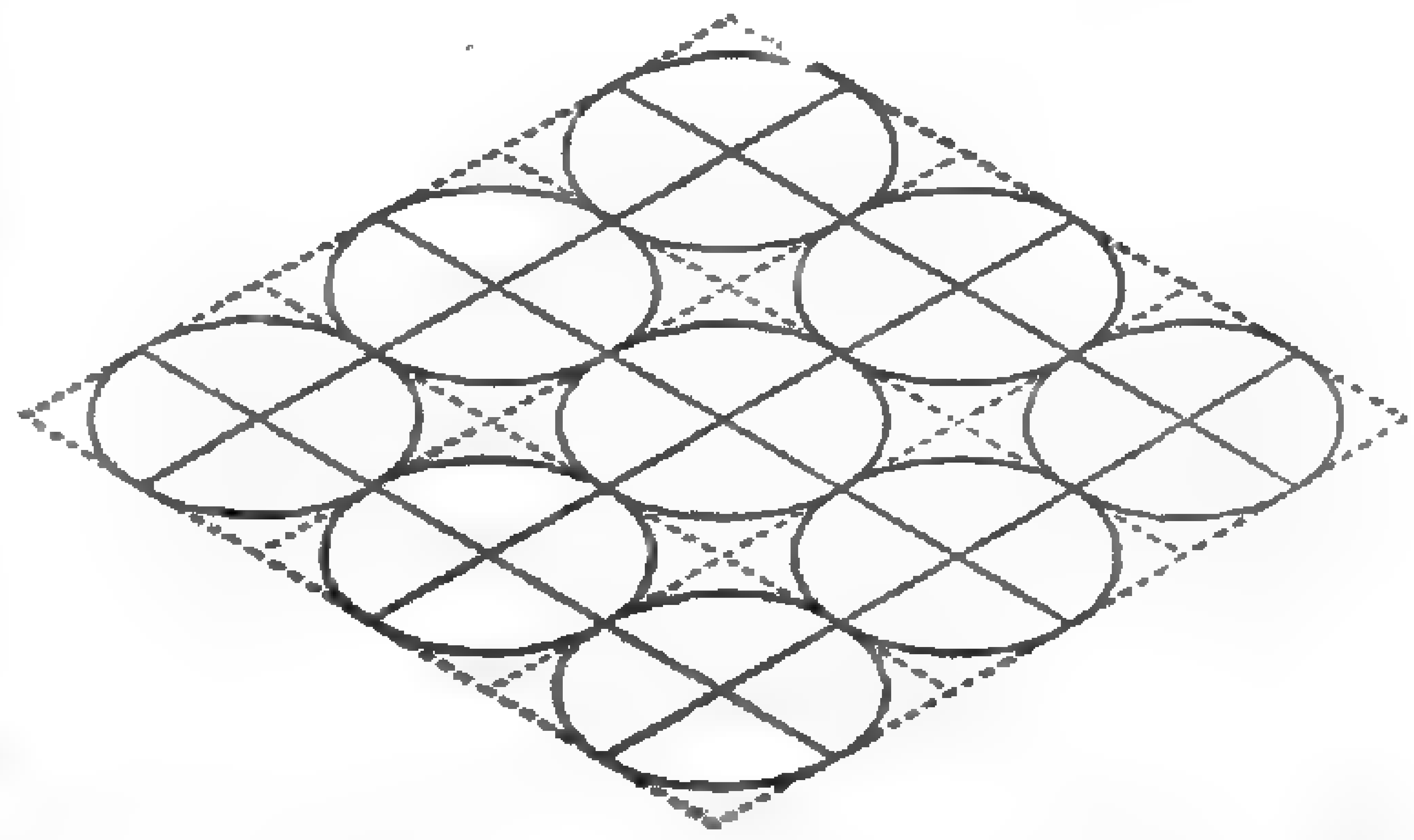


parallel to the shorter diagonal of the rhomb section, and in several of the specimens I have examined it was quite symmetrical. A study of these specimens led me to an explanation of the cause of the remarkable variation of the optical angle, which I believe not only applies to the vermiculites and ripidolites, but also, in many cases at least, to the micas. It would be expected that the several members of such macles as fig. 2 represents would penetrate each other, and I therefore made a series of experiments to ascertain what would be the effect of the interfoliation of laminæ in which the planes of the two sets of optical axes had the same relative position as in the several members of the macle. To that end I divided a plate, which represented the largest optical angle I had observed, into as thin laminæ as possible, and then superimposed them in the relative position I have mentioned, so that the planes of the optical axes should be inclined at an angle of 60°. The result was—when the thickness of the plates in each position was nearly equal—that a symmetrical ring system was obtained, in which the optical angle was about 13°,—the smallest I had measured; and, by varying the relative thickness, intermediate degrees of optical divergence were produced. By now introducing laminæ into the compound crystal, in the position of the third member of the macle,—that is, with the plane of the optical axes in the position of the third diagonal of the hexagon,—the apparent angle could be reduced still further, so that the plate was apparently uniaxial. Although these experiments were sufficient to show that the macling was an adequate explanation of the apparent variation of optical angle I had observed in the plates of ripidolite and Jefferisite, they also raised the question how far the effect I had obtained in my experiments might be due to the circumstance, that, on account of the deep color of these minerals, it is only possible to experiment on very thin plates, with which, of course, the rings of interference are very wide, and the hyperbolas proportionally indefinite. I therefore next made a similar experiment with a well known phlogopite mica from Jefferson County, N. Y., whose crystals are very distinctly macled after the type of fig. 2, or 4, the plates presenting a variation of optical angle similar to that I have described, the normal axial divergence being about 15½°. A very clear portion of one of these plates was first cut into a regular hexagon, one of whose diagonals was in the plane of the optical axes. This hexagonal plate was then split into twelve laminæ, which were superimposed with the intervention of balsam, and in alternating positions, like the members of a macle,—the optical plane in each of the laminæ making an angle of 60° with that of the lamina above or beneath it. The result was an essentially uniaxial plate, differing from a plate of uniaxial mica only in small irregularities in the contour of the rings, such as the lamination would be expected to produce. On repeating now this experiment with a Muscovite mica having a wide optical angle about 63°, I obtained a most remarkable and unexpected result,—a structure presenting optical phenomena similar to those of a plate of quartz cut perpendicularly to the principal axis. At the first trial I obtained a compound mica plate showing a disc of color in the center of the field whose tint changed during the rotation of the analyzer,—of the polarizing microscope,—like a plate of left-handed quartz; and, on superposing a plate of right-handed quartz, the spirals of Airy at once appeared. The rings, however, were wholly broken up, and appeared only in irregular patches of color. This irregularity was due to the unequal thickness of the laminæ employed, and I found it impossible to split up one and the same hexagonal plate of mica into laminæ, which were sufficiently uniform for the purpose. But very satisfactory results were obtained in the following way. I selected for the purpose the very clear and easily cleavable mica from Grafton, N. H.; and, after a few trials, succeeded in cleaving off very thin plates of considerable size and nearly uniform thickness. Selecting one of these plates, I first divided it by means of a parallel ruler into strips, and from these strips cut out the hexagonal laminæ by means of a steel pattern carefully made. The thin mica can be cut with perfect accuracy by a sharp knife on a plate of glass. The hexagonal laminæ thus obtained, though coming from different parts of the mica plate, were optically parallel to each other; and by drawing at the outset a line, with a sharp point, near the corresponding edges of the several strips, this line served as a guide for placing the hexagonal laminæ. From laminæ thus prepared, plates were made showing the familiar system of rings as perfectly as could be expected. The best results were obtained from plates consisting of from twelve to twenty-four laminæ; and the character of the resulting plate, whether left or right-handed, was found to depend on the order of the spiral arrangement. If in building up the pile the marked side of each successive lamina is turned through an angle of 60° in the direction of the motion of the hands of a watch, the result corresponds to left-handed quartz, if turned in the reverse direction to right-handed, and on superposing two dissimilar plates thus prepared I obtained again the spirals of Airy in great perfection. Thus, then, it appears that, even with micas of the widest optical angle, we can build up a structure which is optically uniaxial.*

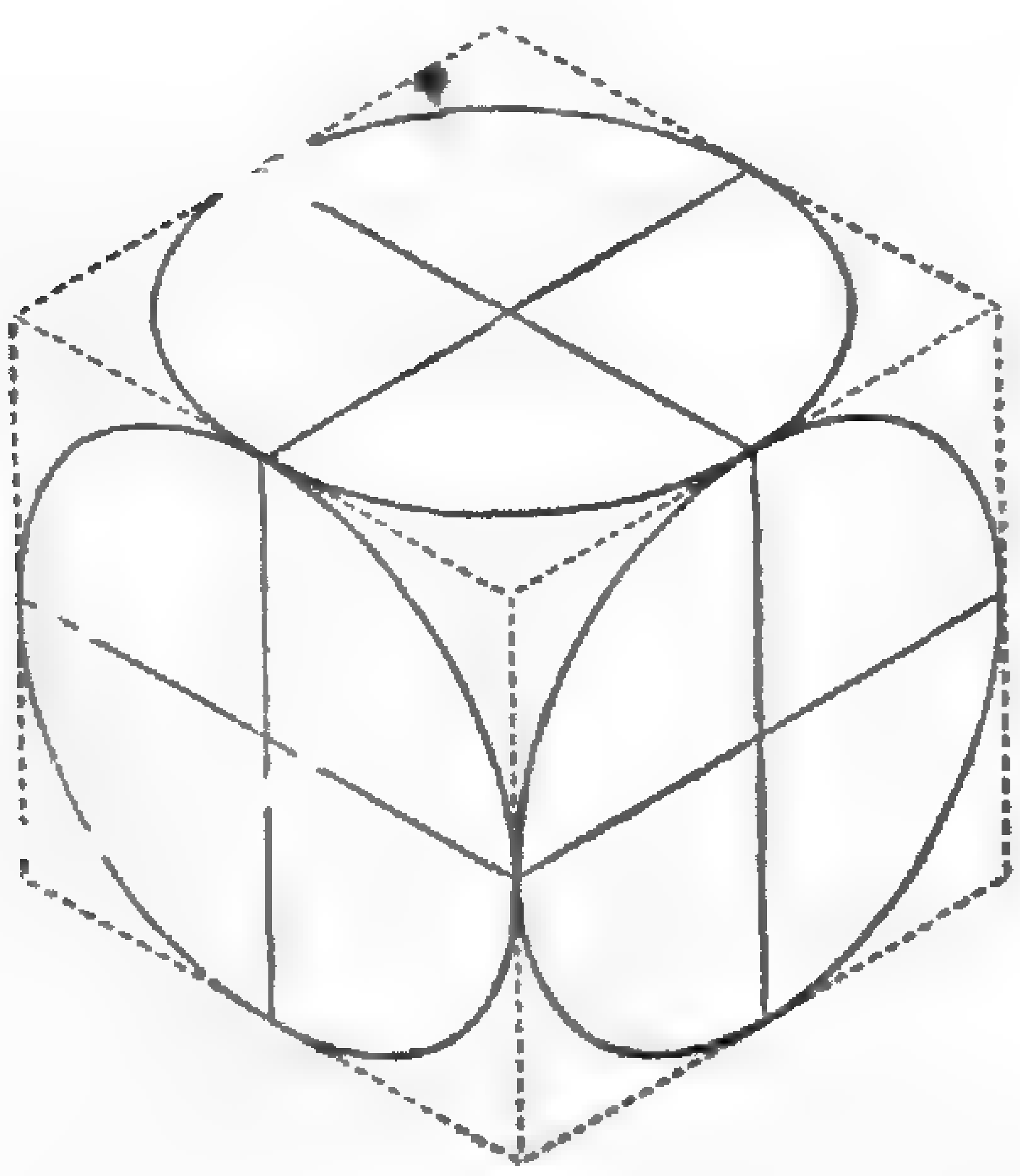
* The great difficulty in preparing these plates is to obtain thin films of mica of uniform thickness, which are of sufficient size to yield a dozen or more laminæ; and the more nearly we have succeeded in preparing such a film, by splitting sheets of mica, the more closely we have been able to imitate the phenomena seen under like conditions with a plate of quartz. We have been able to work with films which measured with a spherometer only $\frac{1}{400}$ of an inch in thickness, and have not obtained good results with those which were much thicker, and when thinner than this the mica cannot readily be cut into shape. The least inequality in the thickness of the several laminæ composing the same plate more or less mars the effect; and, although some of the striking features seen with quartz may remain, such as the succession of colors on revolving the analyzer, and even the spirals of Airy, yet the more delicate phases of the phenomena disappear. The plate changes color when revolved on its own plane, the rings lose their circular form and become confused, and the violet cross disappears. Moreover, as regards the conditions which determine the phase of the circular polarization, the law

The theory which I have formed to account for these facts is as follows. We may conceive that the molecule of mica is an ellipsoid, whose elliptical section, through the longer axis, can be inscribed in the rhomb of 60° and 120°. Assume now that these molecules have polarity, the rhombic prism would be the normal result of their association, as represented in fig. 3. We may, however, conceive that three of these molecules may become associated by alternate single poles to form a nucleus, such as represented in fig. 4. Such a group once formed would be in a condition of great stability, resulting from the concurrent action of the several poles;

3.



4.



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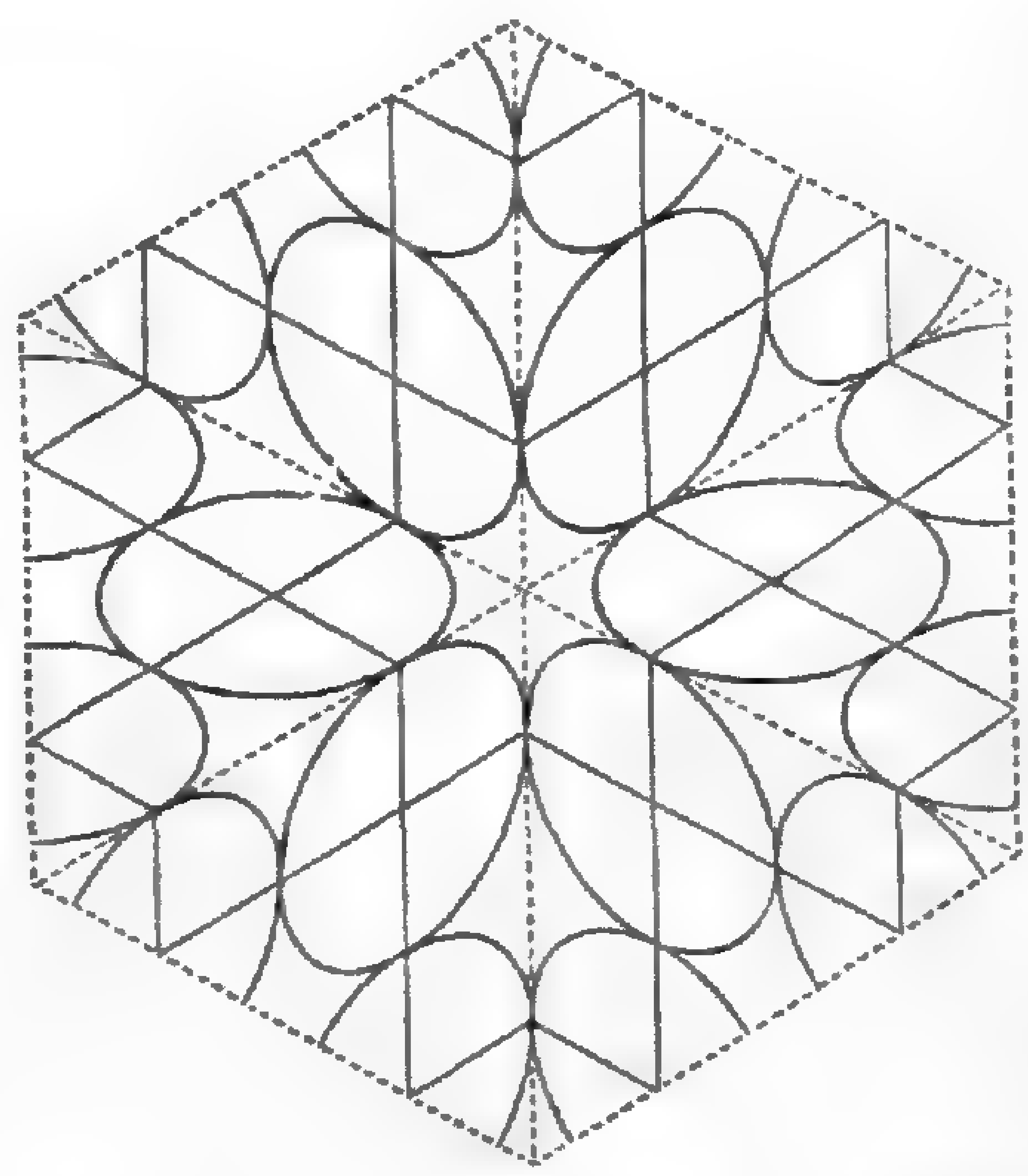


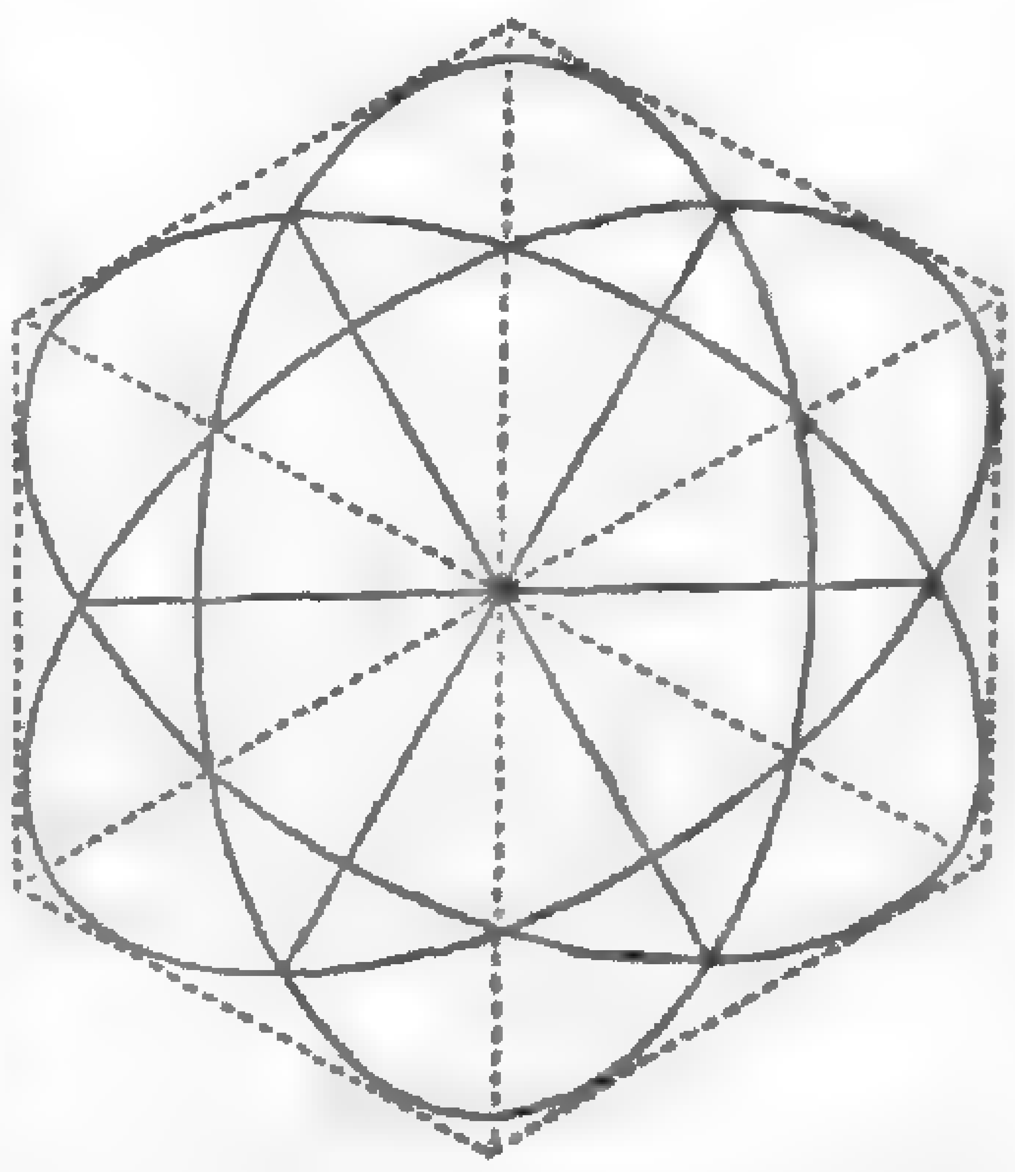
and if now each of the molecules develops into a crystal, the result would be a macle of a form which is very common in the mineral kingdom. If six molecules unite in a similar way to form a nu-

stated above can only be affirmed with certainty of plates consisting of laminæ which very nearly fulfill the conditions we have described. Very small inequalities of thickness renders the effect irregular, and made it at first difficult to discover the law. Our experiments have been a series of approximations; and, although we may never be able with our rude appliances to compete with nature in the manufacture of uniaxial crystals, yet we have approached so near to the perfect result as to be able to point out with confidence one way, at least, by which the effects seen in natural crystals may be produced. We have usually cut the laminæ into regular hexagons, but equilateral triangles might more easily be cut, and would probably give as good results; for, although the errors of position might not be so well distributed, we have found that a slight variation in the relative position of the laminæ injures the result to a far less degree than the least inequality in their thickness. It still remains to make careful quantitative measurements of the effects produced under determinate conditions; and, as can easily be seen, the subject opens a wide field for mathematical analysis as well as physical investigation.

cleus, as in fig. 5, we should also have stable equilibrium (although less firm than before), and the result of a symmetrical development would be a macle such as has been represented in fig. 2. Whether this more complex arrangement is necessary in order to explain the phenomena presented by the vermiculites and micas, I do not feel confident. It is seldom that more than three individuals can be distinguished on a given plate; and the very unequal development of the several individuals, and the indefiniteness of the lines of demarcation, resulting from the phenomena which have been described, render what would seem to be a characteristic feature of the more complex group not necessarily a certain indication of the structure. I refer to the fact, very constantly noticed, that the plane of the optical axes is parallel to the nearest hexagonal edge, as shown in fig. 2. In figs. 4 and 5 this same plane is parallel to the shorter axis of the ellipse! and it can easily be seen that if either of the individual of fig. 4 were developed over any large portion of the space of its neighbors, the optical plane might appear parallel to the adjacent edge.

Having made the two suppositions, as above, to explain the phenomena of twinning, which have been long familiar and externally visible, it will not, we trust, appear unreasonable if we make a third supposition to explain the phenomena first described in this paper. We may conceive that the ellipsoidal molecules, instead of grouping together on the same plane, become associated by their alternate poles, one over the other, as represented in fig. 6. Molecules so associated, developing laterally, would produce the laminæ of a mica plate in the relative position in which we have placed them in our artificial crystals, with only this difference, that the laminæ would be indefinitely thin, and in exact position; and the effect of such compound molecules in modifying the elasticity of the crystalline structure must be, in most respects at least, like that of single molecules, symmetrical on all sides of one line or axis,—in other words, they must produce a structure similar to that of uniaxial crystals. Under what further conditions the grouping of the molecules, in right or left-handed spirals, determines the phenomena of right or left-handed circular polarization, and what bearing the new facts may have on the received theory of these phenomena as they appear in quartz, must be left for further analysis to discuss.

6.



I pass next to consider the composition of the Culsagee vermiculite, and I give below, at (1), (2), and (3), the results of three analyses, made by myself, together with the corresponding oxygen ratios.

The pulverized mineral, after it has been exfoliated by heat, is easily and perfectly decomposed by hydrochloric acid. In analysis (1), after the separation of the silica, the alumina and ferric oxide were separated from the magnesia by ammonia, with the usual precautions. In (2) and (3) the bases were converted into nitrates and separated by Deville's method. In each case the magnesia was weighed as pyrophosphate, and the alumina and ferric oxide were weighed together.

All three analyses were made with material rendered anhydrous by ignition until the weight was constant, and each is represented by three distinct determinations; namely, the weight of the silica, the sum of the weight of the alumina and ferric oxide, and the weight of the magnesic pyrophosphate. The oxides of iron and the water were once for all determined on separate portions of the dried but not exfoliated mineral, and therefore appear of the same value in all the analyses.

The determination of the water was the only difficulty which the analysis of this mineral presented. It is by far the most hygroscopic silicate I have ever examined, when once dry absorbing water from comparatively dry air with almost as much avidity as chloride of calcium. In two experiments with different portions of the same powder, the material was heated in an air bath, at 100° C., for seventy-two hours before the weight became constant; and in each case the weight was compared at intervals of about six hours. The total loss in the first experiment was 10·27 per cent, and in the second 10·19 per cent. The mineral thus dried, lost, when ignited, 10·84 per cent. Another portion of the same powder, which had been dried over sulphuric acid for more than two months, lost, when ignited, 11·09 per cent. This close agreement indicates that all the water lost in drying, either at 100° or over sulphuric acid, is hygroscopic; and the conclusion is confirmed very greatly by the fact that the mineral in thus drying does not change its aspect in the least degree, and rapidly reabsorbs the water when exposed to the air. On the other hand, when the mineral is ignited, it swells up to many times its volume, like other members of the vermiculite family, and undergoes what is evidently a profound alteration in its molecular structure.

	$\ddot{Si}$	$\bar{\bar{Al}}$	$\bar{\bar{Fe}}$	$\dot{Fe}$	$\dot{Mg}$	$\dot{H}$	
(1)	37·58	19·73	5·95	0·58	25·13	11·09	=100·06
	20·04	9·19	1·78	0·14	10·05	9·86	
	20·04	10·97		10·19		9·86	
	2·03	1·11		1·03		1·	
(2)	37·43	19·75	5·95	0·58	25·58	11·09	=100·38
	19·95	9·20	1·78	0·14	10·23	9·86	
	19·96	10·98		10·37		9·86	
	2·03	1·11		1·05		1·	
(3)	37·10	20·22	5·95	0·58	25·07	11·09	=100·01
	19·79	9·42	1·78	0·14	10·03	9·86	
	19·79	11·20		10·17		9·86	
	2·	1·13		1·03		1·	

It is evident from these analyses that the atomic ratio of the mineral is 2 : 1 : 1 : 1, and its formnla may therefore be written :—

$$R_3, \mathrm{R} . O_{12} . Si_3 . 3H_2 O.$$

By referring to what has already been said of the relation of Jefferisite to the biotites, it will be seen that, while that mineral corresponds to a less common variety of this species, the Culsagee vermiculite corresponds to its more usual type. We give below, at (1), the results of an analysis of Vesuvian Biotite, by Chodnef; and, at (2), the same, assuming that a portion of the iron is in the ferrous condition, as is well known to be the case, in order to show that values within the probable error of the analysis would give the ratio 2 : 1 : 1. Here, of course, the alkali takes the place of a portion of the magnesia of the vermiculite.

	Si	Al	Fe	Fe	Mg	Ca	K	
(1)	40·91	17·19	11·03		19·04	0·30	9·96	=98·43
(2)	40·91	17·19	7·03	4·00	19·04	0·30	9·96	=98·43
	21·82	8·30	2·11	·89	7·62	0·09	1·69	
	21·82	10·41		10·29				
	2·12	1·01		1·				

This new variety of vermiculite is so well marked, and the composition so definite, that I have thought best to designate it by the name Culsageeite. As regards its other characters, it has a specific gravity of 2·225 (taken in alcohol), and about the hardness of talc. Before the blowpipe the exfoliated mineral fuses readily to a white enamel, but does not fuse in the flame of a Bunsen lamp.

To this variety of vermiculite belongs, as I have already intimated, the original mineral from Millbury, analyzed by Crossley. There can be no question as to the general accuracy of Crossley's results; and, assuming that all the iron is in the ferric condition, they give, as I have shown, almost precisely the atomic ratio 2 : 1 : 1 : 1. The only question that can arise is in regard to the condition of the iron. I have therefore made an assay of the iron by the accurate method I formerly described in this Journal, xliv, 347, 1867. One hundred parts of the massive mineral gave 7·40 per cent ferric oxide, and 3·86 per cent ferric oxide, which corresponds to a total of 10·56 ferrous oxide. Crossley found 10·02 ferrous oxide, but he separated with great care the vermiculite from the steatite with which it is mixed; and this steatite was probably the source of the greater part of the small quantity of ferrous oxide found in our assay, which, though not made with pure material, shows conclusively that the condition of the iron in the Millbury vermiculite is not different from that in other varieties of the same family of minerals.

Hallite.—Several years since this variety of vermiculite was sent to me by Mr. John Hall, of Philadelphia, by whom it was originally discovered. The examination then made showing that the mineral was a new variety, if not a new species, of the vermiculite family, I gave to it the name of Hallite, in recognition of the mineralogical services of Mr. Hall, who not only discovered the mineral, but has carefully worked the locality and observed the associations in which it is there found. A preliminary notice of the mineral under this name was published at the time by Professor Leeds, of Hoboken; but the interesting relations which the mineral bears to the subject of this paper have made a further examination desirable.

Hallite occurs in large rough six-sided prisms, with easy micaceous cleavage. There are two varieties, differing markedly in color, green and yellow; and I am indebted to Mr. Hall for the following facts in regard to the locality and associations of this species. Mr. Hall writes: "The mineral is found at East Nottingham, in the serpentine formation of southeastern Pennsylvania, three miles south of Oxford, in Chester County; and I know of no other locality. I think the green and yellow varieties are very closely related, and may possibly pass from one into the other; but I have no positive proof that they do. The crystals are found in nests or pockets, and the two colors are not found in the same nests. The green crystals are imbedded in a steatite earth or base of the same color as the crystals, and the yellow in a yellow earth; and sometimes nests, containing the opposite varieties, are only a few feet apart in seams of the serpentine rock."

As the following analyses show, the two varieties have essentially the same composition, and the only difference that could be detected was in the degree of oxidation of the iron. The yellow crystals appeared to be more weathered than the green, and on the last the green color frequently fades out toward the center of crystals, thus giving indications of a metamorphosis by which one variety may pass into the other.

Under the microscope these scales of the mineral show a remarkable appearance. Between the greenish or nearly colorless plates are seen elongated scales of a yellow mineral resembling closely in color thin scales of Jefferisite. They are more or less spear-shaped in form, although usually very narrow, and lie accurately in parallel lines, which cross at angles of 60° and 120°, like the magnetic oxide of iron in the muscovite from Pennsbury, Pa., or the microscopic crystals in the Biotite of South Burgess of Canada; and the phenomenon of asterism, seen so beautiful with the plates of the last, can also be seen with thin laminæ of Hallite. It was impossible to free the mineral from this admixture, but specimens were selected for analysis as free from it as possible. It was also impossible to determine its exact nature. The scales had not a definite form, but there was a tendency to a rhombic shape, which is well described by the term "spear-shaped;" and though the material is so widely distributed through the crystal, the total mass must be very small.

This mineral is not so hygroscopic as Jefferisite, and no difficulty was found in drying the material for analysis. When ignited, it exfoliates like other species of vermiculite, but not nearly to so great an extent as Jefferisite. After ignition it is decomposed by hydrochloric acid. The specific gravity of the green variety, mean of four determinations, 2·398; that of the yellow variety, mean of two determinations, 2·402. Before the blowpipe fuses with difficulty to a brown enamel. The following analyses were made by Mr. C. E. Munroe, Assistant in the Laboratory of Harvard College:—

GREEN VARIETY OF HALLITE.

	$\tilde{Si}$	$\bar{Al}$	$\bar{Fe}$	$\dot{Fe}$	$\dot{Mg}$	$\dot{K}$	$\dot{H}$
(1)	35·97	7·61	8·83	1·13	31·34	0·43	14·32 = 99·63
(2)	35·80	7·29	8·73	1·13	31·56	0·49	14·33 = 99·33
(Mean)	35·89	7·45	8·78	1·13	31·45	0·46	14·33 = 99·49
	19·14	3·47	2·63	0·25	12·58	0·08	12·74
	19·14	6·10			12·91		12·74
	3·	0·96			2·02		2·
	3·	1·			2·		2·

YELLOW VARIETY OF HALLITE.

	$\tilde{Si}$	$\bar{Al}$	$\bar{Fe}$	$\dot{Fe}$	$\dot{Mg}$	$\dot{K}$	$\dot{H}$
(1)	35·17	7·74	9·76	0·32	31·61	0·56	14·65 = 99·81
(2)	35·34	7·42	9·61	0·32	31·41	0·65	14·91 = 99·66
(Mean)	35·26	7·58	9·68	0·32	31·51	0·61	14·78 = 99·74*
	18·81	3·53	2·90	0·10	12·60	0·10	13·14
	18·81	6·43			12·80		13·14
	3·	1·03			2·04		2·09
	3·	1·			2·		2·

$$R_{12}, \bar{R}_2 \,.\, O_{36} \,.\, Si_9 \,.\, 12H_2O.$$

It will be seen from the above analyses that, although the atomic ratio between all the basic radicals and the silicon is the same as in Culsageeite, Jefferisite, and Biotite, the ratio between the protoxide and sesquioxide radicals is very different. In this respect the mineral resembles the phlogopite micas, in which also the protoxide radicals preponderate; and the symbol given above for Hallite, less the water, is identical what that given by Prof. Dana as the more probable formula of the phlogopites.

The opacity produced by the interspersed material made it difficult to determine the optical characters of the mineral, as the rings produced with polarized light could only be seen with very thin plates, and the cross was therefore ill defined; so that, although in some cases there appeared to be a separation of the hyperbolas, the plates could not be distinguished from uniaxial. On one specimen the hexagonal form was very perfect, and the crystal presented the planes of a rhombohedron having an angle over the basal edge of about 12½°, resembling the crystals of Biotite from Greenwood Furnace. Mr. Hall informs me that these more perfect crystals have only been found in one pocket of the serpentine.

The distinction, however, between the phlogopites and the biotites is not fundamental, either chemically or physically.

* Trace of manganese.

Chemically, both species are orthosilicates; that is, the atomic ratio between the silicon and the sum of the basic radicals is 1 : 1. The species differ in composition only in the relative proportion of the sesquioxide and protoxide radicals. In the phlogopite the ratio of $\overset{\text{II}}{R}$ to $\overset{\text{VI}}{\text{R}}$ is probably normally 2 : 1; but of the published analyses the value varies between that ratio and the ratio 3 : 2. In the biotites the same ratio is probably normally 1 : 1; but here, again, the different analyses which have been made give values varying between 5 : 3 and 1 : 2. In like manner the optical distinction between the phlogopites and biotites, of which so much has been made, is equally indefinite. Between a so-called phlogopite, like that from Jefferson County, N. Y., with an angle of about 15°, and the apparently uniaxial plates of biotite from Vesuvius, there is every possible gradation—sometimes, as I have shown, on one and the same mica plate; and I have endeavored in this paper to explain the cause of this variation. With the Vesuvian biotites themselves,—if the specimens in the mineralogical cabinet of Harvard College are fair representatives of the mineral from this locality,—it is only occasionally that we find a perfectly uniaxial plate. More commonly there are distinct evidences of twinning, and on the borders of the hexagonal plate may be discovered a biaxial structure of which the optical plane is parallel to different edges of the hexagon on different parts of the plate.

It must, however, be remembered that, as by the process of twinning we have described the structure of the magnesian micas approaches that of uniaxial crystals, rhombohedral and other planes characteristic of the hexagonal system begin to appear on the crystal. This is illustrated not only by the crystals of Biotite from Vesuvius and from Greenwood Furnace, N. Y., but also by the more perfect crystals of Hallite from Chester County, Pa. In other words, *the process of twinning we have illustrated in this paper produces hexagonal crystals in external form as well as in optical characters;* and the question naturally arises, May not the hexagonal crystals of other minerals be formed in a similar way?—that is, may they not be developed from twinned molecules, which, though in their aggregate producing an hexagonal structure, singly would develop into biaxial crystals? Bearing on this point, we have discovered some very remarkable evidence.

We have in our possession a plate of Elba tourmaline cut perpendicular to the axis, in which the polarizing microscope shows on different zones a separation of the hyperbolas, which amounts in some positions to eight degrees; and in moving the plate across the field the optical divergence varies precisely as on plates of phlogopite and vermiculite. There is certainly no external evidence of lamination on tourmaline crystals, for the mineral is remarkably compact, and the crystals have not even a basal cleavage: but it will be remembered how readily some of the varieties pass by alteration into micas of the magnesian type; and this change to a foliated structure, in which the lamination is parallel to the base of the original hexagonal crystal, may be facilitated by a grouping of the molecules of the tourmaline, in the manner represented by fig. 6.

We have also a plate of amethystine quartz, in which a beam of parallel polarized rays of light exhibits a twinning almost as symmetrical as that shown in fig. 4,—the three zones being most beautifully mapped out by the alternating bands of right and left-handed quartz, which are such a familiar phenomenon of these crystals; but, besides this, in each of these zones, near the border of the plate, can be distinguished a biaxial structure with an optical divergence of several degrees; and, on one other plate of amethyst we have had an opportunity of examining, we have also seen under the polarizing microscope the biaxial curves at one or more points.

These facts most distinctly suggest the theory that the optical phenomena of quartz are produced by a molecular structure similar to that by which we have obtained identical phenomena in our artificial plates of mica, and that the two orders of crystals are aggregates of compound molecules, whose parts are twinned together in the one case in right-handed, and in the other in left-handed spirals, and, lastly, that the simple molecule, if developed normally, would produce a biaxial structure.* This theory is most markedly in harmony with the chemical relations of silica. The compound $Si\,O_2$ is the only one of the tetrad oxides which crystallizes in the hexagonal system; and ever since, by the study of the organic compounds of silicon, the quadrivalent character of the element has been made evident, this fact has been a striking anomaly in our chemical classification. Assume, however, that the molecule $Si\,O_2$ would develop normally into a rhombic structure, and that the hexagonal form of quartz is solely a result of molecular twinning, and the anomaly disappears. The molecule $Si\,O_2$ may be approximately of the same form as the molecule $Ti\,O_2$, in Brookite; but, having the exact dimensions and polar conditions which favor the mode of molecular twinning, described above and represented by fig. 6, it may always develop into hexagonal shapes.

Are, then, all hexagonal forms thus closely related to the rhombic systems of crystals? And do all molecules of the dimensions and polar conditions illustrated by the figures of this article—that is, those which correspond to the rhomb of 60° and 120°—usually develop into hexagonal forms? May not the whole difference

* Since the above was in type, we have received Am. Jour. Sci., IV., February, 1874, containing a description of the rhombic silica which Prof. Maskelyne, of the British Museum, has discovered in the meteorite of Breitenbach. This new species of silica, which Prof. Maskelyne calls Asmanite, has the form of a right rhombic prism, with an angle of 120° 20′, and the crystals are optically biaxial; but while the specific gravity of quartz is 2·6, that of Asmanite is said to be 2·245. It is perhaps to be expected that such a molecular macling as we have described would determine an increase of density, since thereby three molecules coalesce to form one; or it is possible that the remarks made in regard to calcite beyond apply also to quartz; but still the marked difference remains to be explained.

between an hexagonal and a rhombic form arise from a slight difference of dimensions, which determines a molecular macling in the one case, and a normal development of the single molecules in the other? These questions point out most interesting lines of investigation, and will recall to the mineralogist a number of facts bearing upon the subject. Allow me to refer to two of the most striking and most obvious.

On the crystals of the chrysoberyl, the rhombic angle is 119° 46′; and every mineralogist is familiar with the hexagonal macling, similar to fig. 2, which is very characteristic of this species.* Corundum differs chemically from chrysoberyl, in that a portion of the alumina in the former is replaced by glueina in the latter. Corundum has a perfect hexagonal form, and, fundamentally, may not the only crystallographic difference be that, in consequence of the replacement, a rhomb of 120° changes to a rhomb of 119° 46′? Now we have a plate of macled chrysoberyl, showing the normal wide divergence of the optical axes at certain points on its borders, and a nearly uniaxial structure at the center, where there is an obvious interpenetration between the individuals of the macle, and where the superposition of the several laminæ is most beautifully shown by a polarized beam of parallel rays. We have also a section of the corundum crystal, presenting phenomena similar to those seen with the plate of tourmaline, described above. Further, we have observed like phenomena on a section of phenacite; and, although the last mineral contains silica, yet if the molecules of $Si\,O_2$ are crystallographically equivalent to those of $Al_2\,O_3$, it may be that the molecular structure both of phenacite and of beryl is more closely allied to that of chrysoberyl and corundum than the received theory of their chemical constitution would indicate.

We would not convey the impression that in all these crystals the appearances we have described are strongly marked, or that they have passed wholly unnoticed hitherto. Every one who has become familiar with the optical properties of crystals must have noticed that, with many always regarded as uniaxial, there is not unfrequently in some positions a small separation of the cross into the hyperbolas, which are characteristic of biaxial structure. But these irregularities, although long known, have never been satisfactorily explained. They have been hitherto residual features not accounted for by the received theory of crystalline structure, which explains so satisfactorily the general order of the phenomena observed with the polariscope. We have endeavored in this paper to trace their true significance: first, by showing that the appearances we are discussing are precisely similar to the effects which can be obtained by known means with mica plates; and, secondly, by observing on different specimens of various minerals every intermediate stage between the unmistakable effects of twinning on plates of mica or vermiculite, and the delicate phases of the phenomena, seen with sections of crystals of tourmaline, corundum, or phenacite. One other illustration of our theory.

* See also Dana's System of Min., 5th ed., figs. 154, 155, p. 156.

The rhombic angle of witherite (native baric carbonate) is 118° 30′, and the all but universal hexagonal macling of this species is a well-known fact.* The rhombic angle of aragonite (the corresponding form of calcic carbonate) is 116° 10′, and the much greater divergence of this angle from 120° determines, as is also known, a style of macling which is usually quite different from that of witherite. In the isomeric calcite, however, we have the type of all hexagonal forms. Hitherto the crystalline forms of calcite and aragonite have been regarded as being as widely separated as possible, and a comparison of these two well-known mineral species has furnished one of the most striking instances of demorphism. But may not, after all, the comparatively small physical differences between these two minerals correspond to a crystallographic difference no greater, fundamentally, than the difference between the rhomb of 116° 10′ and the rhomb of 120°?

The macles of chrysoberyl and witherite are illustrations of a general truth, fully recognized in mineralogy, that all rhombic crystals, whose angles approach 120°, tend to form hexagonal macles. The optical phenomena described in this paper certainly suggest the theory that a perfect hexagonal form and structure may be the result of a more fundamental and molecular macling, which results when the angle is exactly 120°.

II. Geology and Natural History.

1. *Eozoon Canadense not a Foraminifer or Calcareous Rhizopod secretion.*—Mr. H. J. Carter concludes a paper on the *Eozoon Canadense*, in the Annals and Magazine of Natural History, for March, as follows:

Nothing can be clearer than all that I have above stated of foraminiferous structure, as seen under an inch-focus compound power, in my infiltrated specimens of *Nummulites*, *Orbitoides*, &c., from the Eocene formation of western India.

But in vain do we seek, in the so-called *Eozoon Canadense*, for the unvarying perpendicular tubuli, *sine quâ non* of foraminiferous structure. In vain do we look for that regularity of chamber-formation which, in the amorphous growth assigned to the so-called *Eozoon*, might be equally well assumed to be identical with the heterogeneous mass of chambers on each side of the central plane of *Orbitoides dispansa*, accompanied by the transverse bars of stoloniferous structure uniting one chamber to the other. In short, in vain do we look for the casts of true foraminiferous chambers at all, in the grains of serpentine; they, for the most part, are not subglobular, but subprismatic.

With such deficiencies, I am at a loss to conceive how the so-called *Eozoon Canadense* can be identified with foraminiferous structure, except by the wildest conjecture; and then such identification no longer becomes of any scientific value.

Having examined the slice of Laurentian limestone which you have so courteously submitted to me, in thick and thin polished

* See figures, Dana's System of Min., p. 697.

sections, mounted in Canada balsam, by transmitted and also reflected light, also the surface of the "decalcified" slice as it came from you, in all directions, with one-quarter- and one-inch focus compound powers respectively, I must unhesitatingly declare that it presents no foraminiferous structure anywhere. Nor does its structure bear so much resemblance to that of a foraminiferous test as the legs of a table to those of a quadruped; while, if such be the grounds on which geological inferences are established, the sooner they are abandoned the better for geology, the worse for sensationalism!

The contents of this letter are open to no controversy. My knowledge of foraminiferous structure has been obtained step by step, beginning with the recent and then going to the fossilized forms, making and mounting my own sections, from which afterward my illustrations and descriptions have been taken. If others who have pursued a similar course of instruction differ from me in what I have above stated, the question can only be decided by a third party, not on verbal arguments alone, but on a comparison of the actual specimens, as prolonged disputation, in matters of opinion, soon disgusts everybody but the combatants, and can end in nothing but a fearful waste of time that might be better employed.

2. *Note on the Geology of Costa Rica.* (From a letter to the editors, dated Limon, Costa Rica, Feb. 7th, 1874.)—Nearly all of the year 1873, I have been in the mountains of southeast Costa Rica, with a corps of assistants. In that time, besides good sized collections, half a dozen large vocabularies and the first topographical map ever made of the region, I have some interesting notes on the geology. I expect shortly to commence the ascent of the volcanoes, and, before you receive this, may have the pleasure of standing, the first white man, on the top of Pico Blanco, and with a Green's barometer.

An unexpected result, suspected this half-year past, has just received proofs, in a trip that I made along the cañon of the Reventazon River. The sedimentary rocks of the Atlantic slope of Costa Rica, usually highly metamorphosed, and all of the same geological age, are certainly Tertiary. By means of fossils collected at various points, over a distance of more than 100 miles, I am convinced not only that they are Tertiary, but that they are later than the Eocene. This was so unlike my preconceived idea that I was extremely reluctant to admit the fact, while I found species of molluscs, identical with some found by Dr. Maach on the isthmus, and by myself in the late Miocene of Sto. Domingo. Besides this specific identity, the facies of all the species is exceedingly modern, and I shall not be surprised if comparison should prove some of them to be still living.

From the well known existence of the Cretaceous in the West Indies and Columbia, and from the asserted finding, by Dollfuss and Montserrat, of Jurassic in the States farther north, I suspected that these rocks were secondary, more especially since they are auriferous, in the same manner and under the same circumstances as the Cretaceous of Sto. Domingo. Wherever dykes cut up the metamorphic shale and sandstones, auriferous quartz veins occur; and placer deposits exist in most of the streams that run from the margins of the volcanic belt.

3. *More human skeletons from the Caves of Mentone.*—M. RIVIÈRE read a paper, on the 23rd of February, before the Academy of Sciences of Paris, on three new skeletons from the caves of Mentone. In it he states that the chipped flints disappear below and become replaced by implements of sandstone and limestone.

4. *Mines and Mining in the States and Territories West of the Rocky Mountains: being the Fifth Annual Report (for 1872) of* ROSSITER W. RAYMOND, U. S. Commissioner of Mining Statistics. 550 pp. 8vo, with many plates. Washington, 1873. (Government Printing Office.)—The present volume contains several papers of permanent value and much interest; for example, that on the treatment of gold-bearing ores in California, by Mr. G. P. Deetken, of Grass Valley. This paper presents not only the mechanical details of the Grass Valley system of crushing and amalgamation, but full details of the chlorination process of Plattner, so ably conducted and modified by Mr. Deetken, now for many years at Grass Valley. The contributions to the records of lead smelting in blast furnaces, by Mr. A. Ellers, compares the experience of the far western United States with the best European experience, while Mr. Ellsworth Daggett, in another paper, gives the economical results of smelting in Utah, to which Mr. Daggett's own contributions are quite important. Mr. Amos Bowman's chapter on "The Pliocene Rivers of California" presents the results of an extended series of observations made for the geological survey of the State, while Mr. Charles Waldeyer presents a paper on "Hydraulic Mining in California," illustrated by the remarkable experiences at the famous Spring Valley Company's works at Cherokee, Butte County, California, which is the most systematic and thorough discussion of this curious subject which has yet appeared. Chapters on ore-dressing and mining-machinery, with miscellaneous statistics, conclude the volume. "The General Geological Map of the United States," by Messrs. Hitchcock and Blake, which accompanies this Report, we have already noticed in this Journal. S.

5. *Mineralogy and Chemistry: Original Researches;* by Prof. J. LAWRENCE SMITH, of Louisville, Ky. 401 pp. 8vo. Louisville, 1873. (John P. Morton & Co.)—In this well printed volume, Dr. Smith has thrown together about fifty of his original contributions, chiefly to mineralogy and chemistry, which have appeared during the past thirty years. A large proportion of them have been published in the pages of this Journal, and the reader will be pleased as he turns the pages to recognize many old acquaintances in this new dress. Few American investigators in these departments have done more good work than Dr. Smith. His memoir on Emery (1850); re-examination of American Minerals (1853); Thermal waters of Asia Minor (1849), and his

various meteoric memoirs, especially his "Memoir on Meteorites" (1855), are among the more elaborate of his valuable contributions. His two papers on the "Determination of Alkalies in Minerals," 1853 and 1872, are very important contributions to analytical chemistry, which have become incorporated into the permanent literature of the science. If full reference to the journals in which the several papers originally appeared had been given, it would have added to the value and convenience of the volume, which also lacks an index. S.

6. *Parthenogenesis in Ferns.*—An interesting paper by Dr. WM. G. FARLOW, late Assistant in the botanical department at Harvard University, and at the time a student in the laboratory of Professor De Bary of Strasburg, entitled *An asexual growth from the Prothallus of Pteris serrulata*, was read in January last at a meeting of the American Academy of Arts and Sciences, and is just printed in its Proceedings. A fern, as is well known, comes to fructification and produces spores without any fertilization. The spores in germinating produce a Liverwort-like structure, the prothallus, on which the two kinds of sexual organs are developed; the fertilization of a cell in the one by a spermatozoid from the other results in the development and growth of the former into a bud and so into a fern-plant. Now Dr. Farlow has discovered in a sowing of the spores of the common *Pteris serrulata*, prothalli which were developing fern-plantlets from their substance quite apart from any archegonium, starting in a different way by a direct outgrowth from the prothallus, beginning with a scalariform duct, but producing plantlets thus far undistinguishable from those which arise from an archegonium through fertilization. The paper is illustrated by figures which show the earlier stages, and the difference between this asexual outgrowth and the ordinary development.

Dr. Farlow, confining himself strictly to the facts of the case and their direct interpretation, does not use the word *parthenogenesis*. But the case seems to be substantially analogous to that of parthenogenesis in Phænogamous plants, the few cases of which that have been probably, if not unequivocally, made out, are much fortified by the present discovery. If it be demurred that the case is one of bud-growth, and therefore not of the nature of parthenogenesis proper; the reply is, that it comes from a parthenogenic spore, which here develops plants without the sexual fertilization of that class of plants. The conclusion, if the facts hold good, is that sexual fertilization, however necessary, is not absolutely necessary in every generation of plants, somewhat as cross-fertilization, however necessary in the long run, is generally unnecessary in every generation, only the rule in the former is far more strict. A. G.

7. *Sarracenias as Fly-Catchers.*—It has not rarely happened that after some curious discovery has been made, and perhaps perfected by a series of observers, it then comes to be seen that the discovery has been long before made, recorded, and forgotten.

Drosera is a case in point, although the sensitiveness of the leaf in responding to organic rather than to inorganic matter—to such matters as it can feed on—was wholly unknown to Roth, and was left for Darwin to demonstrate. As to *Sarracenia*, referring to our notes, last year, on p. 149 and p. 467 of the sixth volume of the present series, we add that the source of the statement in the English edition of Le Maout and Decaisne's Treatise is at length apparent, and may be traced back to its origin. The last volume of De Candolle's Prodromus contains the omitted order *Sarraceniaceæ*. To the character the careful editor added a reference thus,—"De causis quibus insecta in ascidiis cadunt [confer] ad Macbride in Trans. Linn. Soc. 12, p. 48 (gall. in Rev. Hort., 1852, p. 123, et Robinson, l. c.)." This sends us to a long-overlooked paper, in the 12th volume of the Transactions of the Linnean Society, 1818, entitled, *On the power of Sarracenia adunca to entrap Insects, in a letter to Sir James E. Smith, Pres. Linn. Soc., from James Macbride, M. D., of South Carolina;* read Dec. 19, 1815. It appears that this paper, written nearly sixty years ago, was noted and referred to by Decaisne in the first volume of the Revue Horticole, more than twenty years ago; that Mr. Robinson, probably the editor of The Garden, has more recently referred to this, and that Dr. Hooker last year noted either the one or the other. De Candolle's reference "Robinson, l. c.," however, remains a puzzle, as there is no antecedent citation of his name, none under *Sarracenia*, and the one under *Darlingtonia*, upon verification by reference to the Garedner's Chronicle, throws no light on the matter in hand.

Dr. Macbride was a collaborator with Elliott upon the Botany of South Carolina and Georgia, and from all we know, must have been a first-class observer. He died at the early age of thirty-three, between the years 1821 and 1823, that is, between the publication of the first volume and the printing of the first sheet of the second volume of Elliott's Sketch. To his memory Elliott dedicated the distinct and pretty Labiate plant, *Macbridea pulchra*, and in the preface pays a beautiful tribute to him and to Dr. Baldwin, as the two individuals who took most interest in his work, who would have been throughout, as they were at first, the most important contributors to its value, but who "scarcely lived to see the commencement of its publication." On p. 12 of the second volume Elliott refers to this paper of his deceased friend, and gives an abstract of its main points. This reference to so curious a fact, although occurring in a book very familiar to botanists, seems to have been as completely overlooked as was the original paper; doubtless, because botanists, until lately, saw in it only a matter of idle curiosity, and thought it a matter of no consequence whatever whether *Sarracenia* and *Drosera* caught flies or not. Even *Dionæa* excited little more than unreflecting wonder, as an unique anomaly,—as if any member of the organic world stood alone.

Sarracenia adunca is a synonym of *S. variolaris.* It seems to be the most active fly-catcher of the genus, and to offer as a lure the greater amount of the sweet secretion. Dr. Macbride intimates that the open mouth and upraised lid of *S. flava* may favor the escape of the attracted insects after sipping their fill. But more likely the greater success of the former is due rather to the greater abundance of the sweet secretion,—almost certainly so if this stupifies the flies, as Mr. Grady asserts; and to this point should now be directed the careful observation of those who have *Sarracenia variolaris* within their reach. The Director of the Botanic Garden of Harvard University, Cambridge, would be glad to receive a stock of living roots of this species. A. G.

8. *Hooker's Flora of British India*, published by L. Reeve & Co., under the authority of the Secretary of State for India, in Council.—The second part, just issued, carries on the Polypetalous Orders from *Frankeniaceæ* to near the close of *Geraniacæ*, from p. 209 to p. 464, which ends with the 74th (out of 122) species of *Impatiens.* Dr. Hooker has himself re-elaborated this genus; the rest of the order, as well as the *Caryophyllaceæ*, etc., was undertaken by Mr. Edgeworth; Dr. Masters is responsible for the Malvaceous orders; Mr. Dyer for the *Ternstræmiaceæ*, *Dipterocarpeæ*, etc.; and the late Dr. T. Anderson worked out the *Guttiferæ* just before his lamented death. In this flora, unlike the other and very similar British colonial ones, the characters of vegetation are put foremost, both of genera and orders, which seems to us most natural and convenient. A. G.

9. *Pachystigma Canbyi* Gray.—This Alleghanian analogue of the species common from the Rocky Mountains to the coast of Oregon, before the only representative of the genus, was published only last autumn in the Proceedings of the American Academy of Arts and Sciences, although Mr. Canby discovered it a dozen years ago. Being an interesting accession to the Botany of the Northern Atlantic United States, it is well to note that a second station has already been discovered, by Howard Shriver, Esq., of Wytheville, Virginia. He finds it in the vicinity of that town, on the banks of Reed Creek, etc., growing at one place in company with *Carex Fraseriana.* A. G.

10. *Woodsia Ilvensis, why so named?*—In a foot-note in Bull. Soc. Bot. France, 19, p. 138, Dr. Fournier raises the question often asked before, how this specific name *Ilvensis* came to be given to a fern not known to grow upon the island of Elba. The Abbé Chaboiseau, in the next volume of the Bulletin, p. 70, gives the result of his investigation into the origin of the name. It appears, in short, that the name originated with Dalechamp as *Lonchitis aspera Ilvensis*; this was cited by Linnæus in his *Flora Suecica* as a synonym of his *Polypodium fronde duplicato-pinnata*; to this in the Species Plantarum he gives the name of *Acrostichum Ilvense*, omitting, however, to cite the synonym of Dalechamp, and also the habitat which gave the name. M. Chaboisseau thinks it probable that Dalechamp's figure represents a

Woodsia, and if so, the species that Linnæus took it for. Also that, as it is said on good authority to grow in the Crimea, it may really belong also to the mountains of Elba. A. G.

11. *The New Views respecting the nature of Lichenes and their Gonidia.*—The recent bibliography upon this interesting subject is carefully analyzed in the *Revue Bibliographique* of the Bull. Soc. Bot. de France, fasc. 1 of the 20th volume, down to March, 1873—a year ago; from which one gets a good view of the state of the question at that date. M. Bornet's paper, of which we gave some account in our last volume, is one of the latest there noticed. A. G.

12. *Villars*, author of the History of the Plants of Dauphiny, as now appears from a biography by M. Albert, noticed in the *Revue* above cited, really bore the name of *Villar*. As his botanical works were published in his own life-time, and all under the name of *Villars*, it is to be hoped that no one will endeavor to reform the orthography of the genus *Villarsia*. A. G.

13. *Eryngium; species with parallel-veined leaves.*—Prof. DECAISNE made a communication to the Botanical Society of France upon this subject, at the meeting on the last day of January, 1873, which is published in the Bulletin, 20, pp. 19–27. These species are all American, as is the larger part of the genus; and M. Decaisne thinks it a remarkable case, not to say inexplicable upon the now current mode of explaining such things, that the peculiar modification should co-exist with the ordinary forms, and over a wide range. Indeed, the two dozen species with "monocotyledonous foliage" are scattered along the length of the continent, from the Great Lakes at the north to the borders of Patagonia. That this lower form, as indicated by the monocotyledonous foliage, should be confined to the New World, while those with well-developed or compound leaves are common to the Old World also in the northern hemisphere, seems to M. Decaisne incongruous with the reigning ideas of the descent of species and the earlier appearance of the simpler or lower types. He appears to argue that, if the *Eryngia* are all descendants of a primitive stock which had gained a dispersion round the world at the north, before this was "violenment disloquée par le cataclysme qui a séparé le globe en deux continents" [which is highly antiquated geology], then the Old World should have had a share of the "monocotyledonous-leaved" species which, *ex hypothesi*, should have been the more ancient, whereas their less wide diffusion indicates that they are more modern.

Now, in the first place, these species may have been in Europe also in the earlier days, along with many other American types which then abounded but have since disappeared. And in the second place, this peculiarity of foliage may be merely an *adaptive* character, parallel to that of the phyllodineous Acacias of Australia. That such leaves in *Eryngium* are petiolar (and not laminal) in nature is fairly made out by a comparative study of our species. And if the typical species, *E. aquaticum* of Linnæus, lived in the medium implied by the name, this kind of foliage would represent one of the commonest adaptations to aquatic life. It actually grows, however, on drier ground than any other of our species, rendering the name so nearly a misnomer that I have proposed (considering also that Linnæus mixed two or three species under *E. aquaticum*) to drop that name in favor of the later but most appropriate name of *E. yuccæfolium* Michx.

Something like this is probably true of the Mexican and South American species of this group. Even if not themselves aquatic, they are very probably descendants of *Eryngia* which were so, and so inherit an adaptive character which has in its turn been adapted to terrestrial conditions.

From the catalogue which Prof. Decaisne gives of the species represented in the herbarium at the Jardin des Plantes, it is noticeable that several of our United States species are wanting, especially the species of Oregon and California, and *E. Ravenelii* and *E. prealtum* Gray, of the south; of which specimens are desired in order that these desiderata at Paris may be supplied.

A. G.

14. *On the Origin and Metamorphoses of Insects;* by JOHN LUBBOCK. Nature Series. (Macmillan & Co.)—This little book is full of interesting information relating not only to insects, but to various other animals. The facts are presented in a clear and attractive style and are discussed with great candor, in reference to their bearings on the theories of evolution. The illustrations are numerous and well executed. V.

15. *Man and Apes: an exposition of structural resemblances and differences bearing upon questions of affinity and origin;* by ST. GEORGE MIVART. 8vo, with numerous illustrations. New York. (D. Appleton and Co.)—The facts briefly and clearly expressed in this work have important bearings upon the general subject of evolution, as well as upon the origin of man. The general scope of the work is sufficiently indicated by the table of contents: Part I, External form, habits, geographical distribution and classification; II, External skeleton and internal skeleton; III, Nervous system, visceral anatomy, summary of characters and questions of affinity and origin. V.

16. *The Comparative Anatomy of the Domesticated Animals;* by A. CHANEAN, translated and edited by George Fleming. 957 pages, large 8vo, 450 illustrations. New York. (D. Appleton & Co.)—This is a valuable and comprehensive treatise, and is undoubtedly the best manual relating to this subject, in the English language. V.

17. *The Structure of Animal Life. Six Lectures delivered at the Brooklyn Academy of Music, in January and February,* 1862; by LOUIS AGASSIZ. Third edition. New York, 1874. (Scribner, Armstrong & Co.)—This is essentially a mere reprint of the first edition. The typography, otherwise good, is marred by the use of the same rude and often incorrect wood-cuts, apparently copies of hasty black-board sketches, that appeared in the first edition. Many of these are no better than caricatures of nature, for which

we should be sorry to believe that the distinguished lecturer was responsible. V.

18. *Our Common Insects. A popular account of the Insects of our fields, forests, gardens and houses;* by Dr. A. S. PACKARD, Jr. 12mo, with numerous illustrations. (Naturalists' Agency, Salem, Mass.)—Although this is, as stated in the preface, mainly a reprint of various essays that have appeared in the American Naturalist, and elsewhere, it forms an attractive little volume, which will prove useful and interesting to those who are beginning the study of entomology, as well as to many who are interested in the subject from an agricultural or horticultural point of view. V.

19. *Ophiuridæ and Astrophytidæ, new and old;* by THEODORE LYMAN (Bulletin of the Museum of Comparative Zoology, vol. iii, No. 10). 8vo, with 7 plates. Cambridge, Mass., Feb., 1874.—This contains: 1st, critical observations on various species of Ophiurans, either contained in the museum, or studied by Mr. Lyman in the various European collections, together with descriptions of several new species; 2d, a catalogue of the Ophiurans belonging to the museum, collected by Prof. C. Semper in the East Indies; 3d, a discussion of the homologies of the chewing apparatus in Ophiurans. In the first part, the species of *Pectinura*, and the European species of *Ophiothrix* are well discussed, and species belonging to the genera *Ophiopeza*, *Ophiarthrum*, *Ophiomastix*, *Ophioplacus*, *Amphiura*, *Ophionephthys*, *Ophiocnida*, *Ophiopsammium* (nov.), and *Astrophyton*, are either discussed, or described. The plates have been copied from the original drawings, by two of the photographic processes, and have many excellent features. Two are by the Heliotype process, and five are Alberttypes. V.

20. *Transactions of the Connecticut Academy of Arts and Sciences.* Vol. ii, part 2, New Haven, December, 1873.—This contains the following papers: On the direction and force of the wind, with the fall of rain and snow, at Wallingford, Conn., by B. F. Harrison, M.D., and Francis E. Loomis, Ph.D.; Design for a bridge across East River, New York, by Wm. P. Trowbridge; On the mean direction and force of the wind at New Haven, by Francis E. Loomis; Notes on the Geology of Yesso, Japan, by W. P. Blake; Comparison of the muscles of the chelonian and human shoulder-girdles, by H. S. Williams, Ph.D.; Graphical methods in the thermodynamics of fluids, by Prof. J. W. Gibbs; List of marine algæ collected near Eastport, Maine, by Prof. D. C. Eaton; The early stages of the American lobster, by S. I. Smith; A method of geometrical representation of the thermodynamic properties of substances by means of surfaces, by J. W. Gibbs. V.

21. *New genus Euchondria* Meek.—Mr. MEEK states, in a letter to one of the editors, that he proposes to institute the genus *Euchondria* for *Pecten neglectus* of Geinitz, on account of its peculiar hinge as illustrated by figure 7c, plate xxvi, in volume v, of the Illinois Geological Report.

III. Astronomy.

1. *Astronomical and Meteorological Observations made during the year* 1871, *at the U. S. N. Observatory*, Rear-Admiral Sands, Superintendent. Washington: Government Printing Office, 1873.—This thick volume, of over a thousand quarto pages, by its size shows activity at the observatory, and the close print of the pages proves that the size is not obtained by diluting material. The observations of the year, and the introduction, occupy about 350 pages.

The first appendix (170 pp.) contains the zones observed with the meridian circle in 1847–8–9. It is intended to re-observe some of the stars of these zones, to aid in forming from them a catalogue of southern stars.

The second appendix (144 pp.) contains observations made with the mural circle and transit instrument by Prof. Yarnall, from 1853 to 1860.

The third appendix (294 pp.), by Prof. Yarnall, is a catalogue of 10,658 stars, observed at the Washington Observatory from 1845 to 1871, and constitutes one of the most valuable publications that have issued from the institution.

The fourth appendix is a history of the founding and progress of the U. S. N. Observatory, by Prof. Nourse.

2. *New Comet.*—Prof. Winnecke discovered a comet in the constellation Vulpecula, Feb. 20th.

3. *New Planet.*—A telegram from Berlin to Prof. Henry announced the discovery of a new planet by Palisa.

The following names have been given during the past year to minor planets:—(119) *Althæa*, (121) *Hermione*, (125) *Liberatrix*, (126) *Velleda*, (127) *Johanna*, (128) *Nemesis*, (130) *Electra*, (131) *Vala*, (131) *Æthra*, (133) *Cyrene*, (134) *Sophrosyne*.

4. *Engravings from Harvard College Observatory.*—No. 23 of this series contains figures of seven solar prominences. With this is a re-issue of No. 3, containing a representation of the solar disk with spots and colored prominences, compiled from several dates. Four of the earlier numbers have been thus re-issued, that they may correspond in size and character better with the later engravings.

IV. Miscellaneous Scientific Intelligence.

1. *Agassiz Memorial.*—The following circular has been recently issued by the Agassiz Memorial Committee. The object is one that commends itself to all interested in the progress of knowledge throughout the world, as well as to those who would do honor to the name of him who devoted his whole self to the progress of science and especially of American science.—Eds.

In removing Louis Agassiz, death has deprived us of one who, for the last quarter of a century, has done more than any other person to stimulate in this country the study of Nature and a spirit of scientific investigation. Twenty-eight years ago he left Switzerland, his native land, for the United States, and became an American citizen. Those twenty-eight years he gave to unremitted labor in behalf of that higher education, which, by the public at large, was little understood. His interest was confined to no town or State, to no individual or class. * * At the age of sixty-seven his brain gave way, and he died, leaving no wealth but his name, his example, and his works.

It would not be grateful for the country, nor would it be for the country's interest, that Agassiz should pass away without a fitting memorial. Such a memorial can be made out of the great Museum which he began and partially built, and for the completion of which he has left full directions. Completed, it would be a perpetual fountain of knowledge, and a monument quick with his spirit.

"Museum," a word that commonly suggests little more than a collection of curious objects, is scarcely an appropriate name for the memorial that Agassiz ought to have. The Museum he labored for is a presentation of the animal kingdom,—fossil and living,—arranged so as to picture the creative thought. The study of such a subject is the highest to which the human mind can aspire.

At the end of the nineteenth century, no nation, least of all the American, may dare to lag in science; for science is only another word for knowledge, and knowledge is the source of power, and of whatever contributes to power. * * *

Every workman must have his tools: the tools of a zoologist are collections of natural objects systematically arranged. Such an arrangement means the exhibition of the animal creation in its natural order. This is one of the prime difficulties of science, which taxes the powers of the greatest genius. So difficult is it, indeed, that no two leaders of zoology have ever exactly agreed in their views; and it is only by *comparing* these views that the student can judge for himself. Of what incalculable value would collections be if such had been arranged by Linnæus in Sweden, by Oken in Germany, by Cuvier in France! But such museums do not exist. Even the great collections of Cuvier are mingled with those of his opponents, like a book culled from the works of many authors. In this country we may have such a museum if we choose. The celebrated System of Nature of Linnæus can be studied only in books. We may and should have Agassiz's System of Nature illustrated by the specimens which his own hands have set in order. It is for our people to say whether they will neglect this magnificent opportunity to secure a means of education which money cannot buy and the future may not give.

The Museum of Comparative Zoology at Cambridge is an independent establishment, governed by a faculty of its own. It was founded fifteen years ago by Agassiz, and has grown to its present large proportions under his hand. In connection with it is the newly-established School of Experimental Zoology on the Island of Penikese, endowed by Mr. Anderson of New York. The system of instruction has the widest character, and includes elementary teaching, as well as the highest investigations. The exhibition-rooms are free to the public. Large sums have already been expended in bringing this national museum to its present condition. Its collections, in several branches, are superior to those of the British Museum or the Garden of Plants. To make such an establishment useful, it must have a large building, and a considerable annual income for the payment of professors and assistants. To perfect the grand plan conceived by Agassiz will require at least three hundred thousand dollars, of which about one-third would be used in enlarging the building, and two-thirds would be funded.

It is to be hoped that the people of America, for whom Agassiz unselfishly labored, and among whom he spent the best portion of his life, will not hesitate to carry on the work he began. His example and his teachings have benefited every section of the country. The Museum he planned and founded will, if suitably endowed, become an ever-increasing source of scientific and practical usefulness to the nation and the world. We cannot doubt, therefore, that this appeal will be answered by the public in the same generous spirit in which Agassiz devoted his genius to the furtherance of science and to the advancement of education among us.

But we would not appeal to the friends of liberal culture in this country alone. The works and the example of Agassiz are the precious legacy left by him to all nations; and we feel sure that in the great centers of scientific activity in the Old World, where his genius received its first impulses and achieved its earliest triumphs, there will be felt an earnest desire to aid in a work which, while commemorating the labors and influence of Agassiz, will be an enduring source of scientific discovery and inspiration.

The Agassiz Memorial Committee include John A. Lowell, Nathaniel Thayer, George T. Bigelow, John M. Forbes, Abbott Lawrence, Theodore Lyman, Prof. B. Pierce, Charles Francis Adams, Prof. Joseph Henry, Prof. J. D. Dana, and others. Roger Wolcott, of Boston, is Secretary of the Committee.—Subscriptions may be sent to Sebastian B. Schlesinger, Esq., Treasurer of the Committee, 6 Oliver street, Boston.

2. *Cycle of Magnetic declination.*—Mr. SCHOTT, of the Coast Survey, has made an examination of the secular changes in the magnetic elements, based on all the observations taken at Washington since 1790. He finds that the magnetic declination varies in a periodical manner, such as will cause it to return to its present value in about two hundred and forty years. The dip of the needle is now slowly diminishing, and has continued to do so since 1840, its annual change being very nearly uniform. The total magnetic force is very slowly increasing, although at present it is sensibly nearly stationary; it reached its minimum about twenty-two years ago, and, after having increased until the present time, is probably now about to diminish. The hypothesis that the observed secular changes are the effect of thermal changes in the earth's crust, manifesting themselves as a disturbance in the distribution of terrestrial magnetism, seems to the author a plausible

one. These thermal changes must be considered to have a slow rate, but operating on a vast scale, explaining the similarity of secular change extending over thousands of miles, and going on, perhaps, for hundreds of years. They appear to be of a mixed, progressive and periodic character. Thus the influence which produced the increase of the magnetic west declination on our Atlantic coast was first recognized in the northeast, extending itself in time toward the southwest.—X. *Harper's Weekly*, March 28.

3. *Relation between the color of certain Birds and their geographical distribution.*—A communication has lately been made to the Academy of Sciences of Paris, by Mr. ALPH. MILNE-EDWARDS, upon the relations existing between the color of certain birds and their geographical distribution, having special reference to the fauna of Polynesia. His inquiries have embraced not only researches into the absolute fact of melanism in the way of black plumage, but also the degree to which this influence has modified the true colors. Referring to the fact that birds with black plumage are found, in all parts of the globe, in certain families of wide geographical extent, he states that melanism is exhibited decidedly only in the southern hemisphere, and especially in the portion embracing New Zealand, Papouasia, Madagascar and intermediate regions. Thus, in the swans, all the species of the northern hemisphere are white; in New Holland, however, there is a species that is entirely black, while in Chili and elsewhere in South America we have the Coscoroba swan, entirely white, with some of the quills black, differing in this respect alone from the allied species in China.

Again, in speaking of the black parrots, Professor Milne-Edwards remarks that none of these are to be found black in America or Asia, or in Africa excepting along the borders of the Mozambique Channel, though they are not rare in the more southern regions included in the limits mentioned, some of them being entirely black, and others with a gloss of this color, such as to obscure the other tints.—*Ib.*

4. *Proposed Scientific Re-survey of the State of Massachusetts.*—The American Academy of Arts and Sciences at Boston have lately appointed a committee to memorialize the Legislature on a new and complete scientific survey of the Commonwealth—topographical, geological, zoological and botanical. The committee, who will soon act in the matter, are Hon. Chas. Francis Adams, George B. Emerson, Richard H. Dana, Jr., Wm. B. Rogers, Alexander Agassiz, Samuel Scudder and T. Sterry Hunt. Massachusetts was the pioneer in such surveys, and it is time the work was renewed.

5. *Transactions of the American Institute of Mining Engineers.* Vol. I, May. 1871, to Feb., 1873. 475 pp. 8vo. Philadelphia, 1874. Published by the Institute.—The American Institute of Mining Engineers came into existence in 1871, and has held sessions at Wilkesbarre, Bethlehem, Troy, Philadelphia, New York, Pittsburg, Boston, and New York again. This volume

embraces its constitution, lists of members, associates and officers, and most of the important papers which have been presented at its sessions, and bears testimony to the activity of the Institute and the value of many of the papers read before it.

6. *Dictionary of Elevations and Climatic Register of the United States;* by J. M. TOUER, M.D., Washington, D. C. 93 pp. 8vo. New York. (D. Van Nostrand.)—Dr. Touer's Dictionary is a valuable contribution to sanitary science. It is prefaced by a brief introduction on the orographic and other physical peculiarities of North America, and the relation of elevation, rain fall, and other climatic peculiarities to health and disease.

7. *The Birth of Chemistry* (*Nature Series*); by G. F. RODWELL, F.R.A.S., F.C.S., &c. 135 pp. 12mo. London, 1874. (McMillan & Co.)—Mr. Rodwell has made an extremely interesting little volume on a very old theme, which he has treated with equal good taste and learned research. It is a *multum in parvo* and a desirable addition to the chemist's library.

8. *Dunglison's Medical Dictionary, &c.* 1131 pp. 8vo. Philadelphia, 1874. (H. C. Lea.)—Dr. ROBLEY DUNGLISON's Medical Lexicon has for forty years been the standard authority for American medical readers and students. This new edition, by Dr. Rich. J. Dunglison, son of the late author, includes, besides a complete revision of the whole work, an addition of more than six thousand subjects and terms not embraced in the last edition from the author's hand in 1865. The work is very greatly improved.

OBITUARY.

Prof. L. A. J. QUÉTELET died at Brussels on the 16th of February, at the age of 72. At the age of eighteen he was made Professor of Mathematics at the royal College at Ghent. In 1819, at the age of twenty-three, he received the same appointment at the Athenæum at Brussels. From 1828 to his death he was in charge of the Royal Observatory, which was built under his direction. For forty years he has been Perpetual Secretary of the Royal Belgian Academy.

He has edited the *Correspondence Math. et Phys.*, 8vo, 11 vols., 1825–39; the *Annuaires*, the *Bulletins*, and the *Mémoires*, of the Academy; the *Annales* of the Observatory, etc., in all, over two hundred volumes. In addition, he has written a large number of volumes, some of them of a popular character, on Probabilities, Physics, Astronomy, Meteorology, Statistics, Man, and has contributed to the above and other periodicals not less than three hundred articles or memoirs.

Prof. Quételet was the first to announce the annual recurrence of the August meteors, though the discovery was independently made by Mr. Herrick.

The death of the distinguished astronomer MÄDLER is announced by telegraph.

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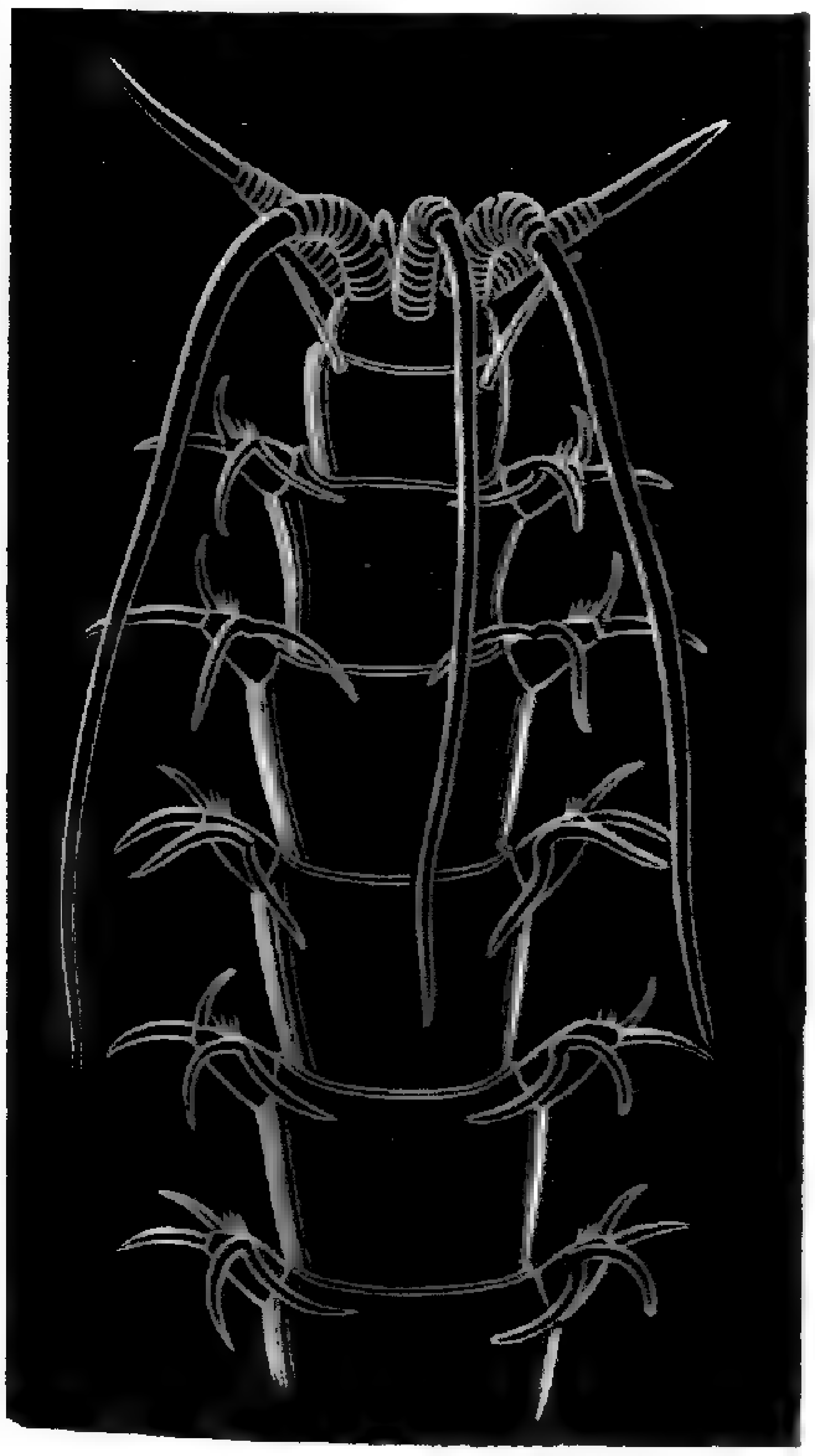

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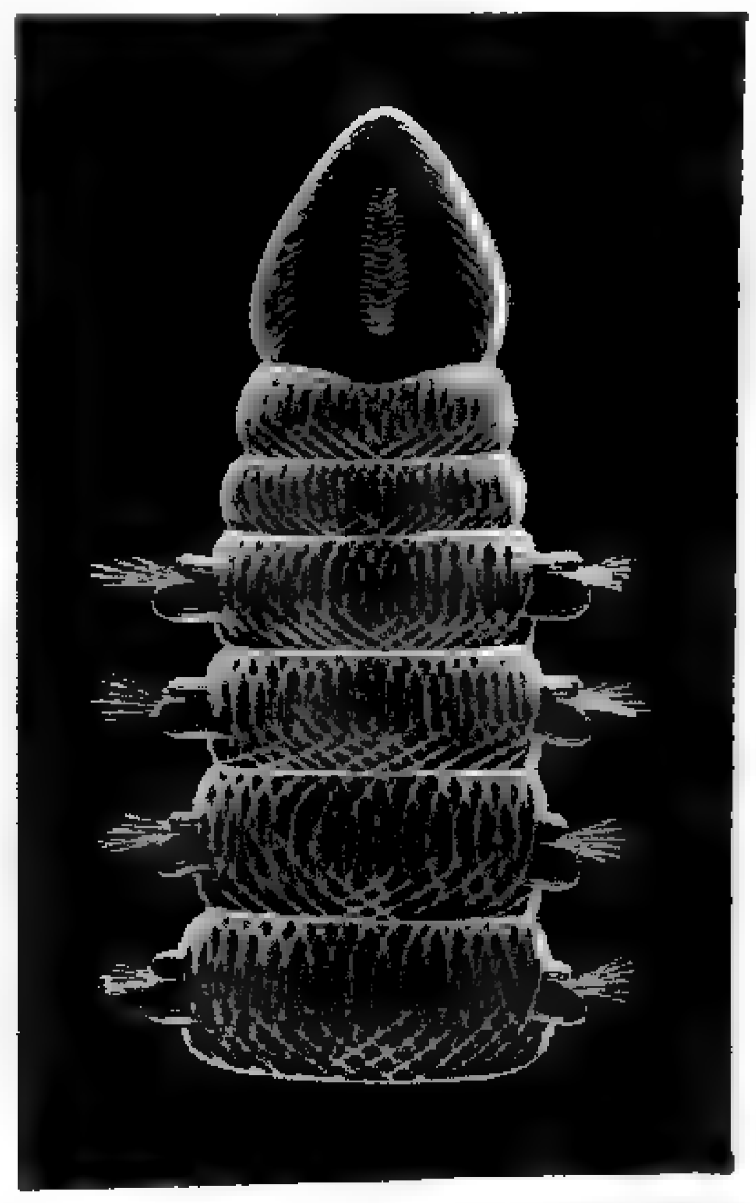

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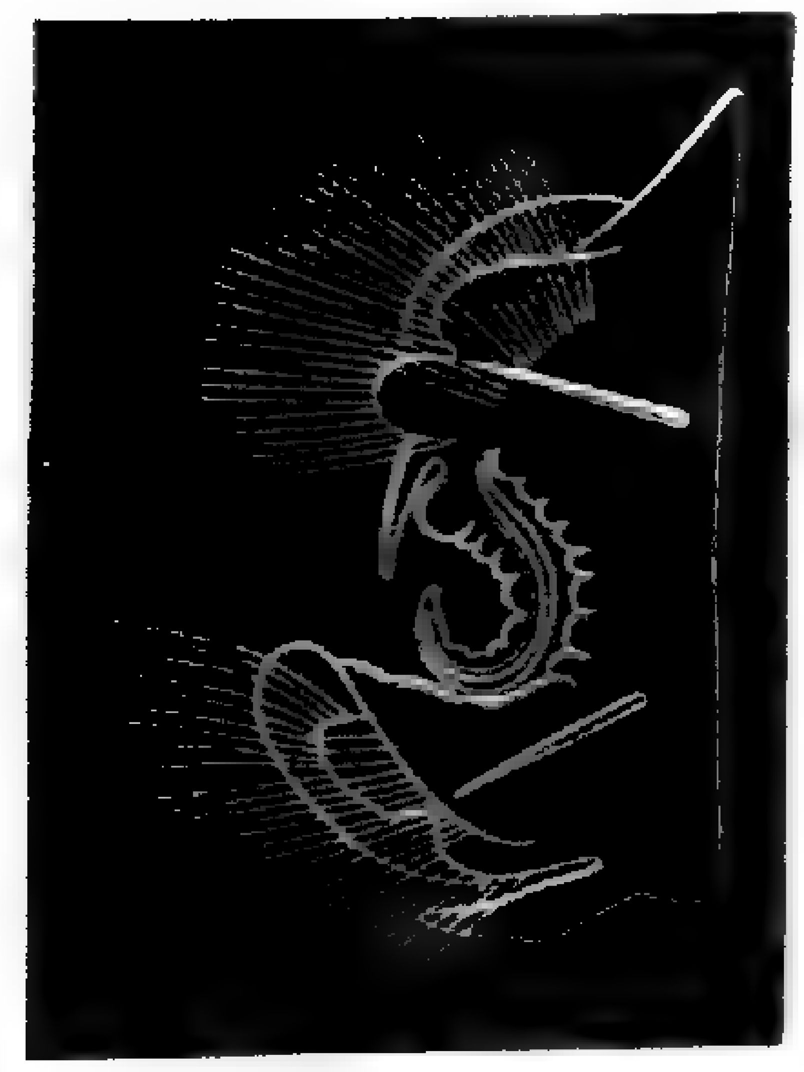

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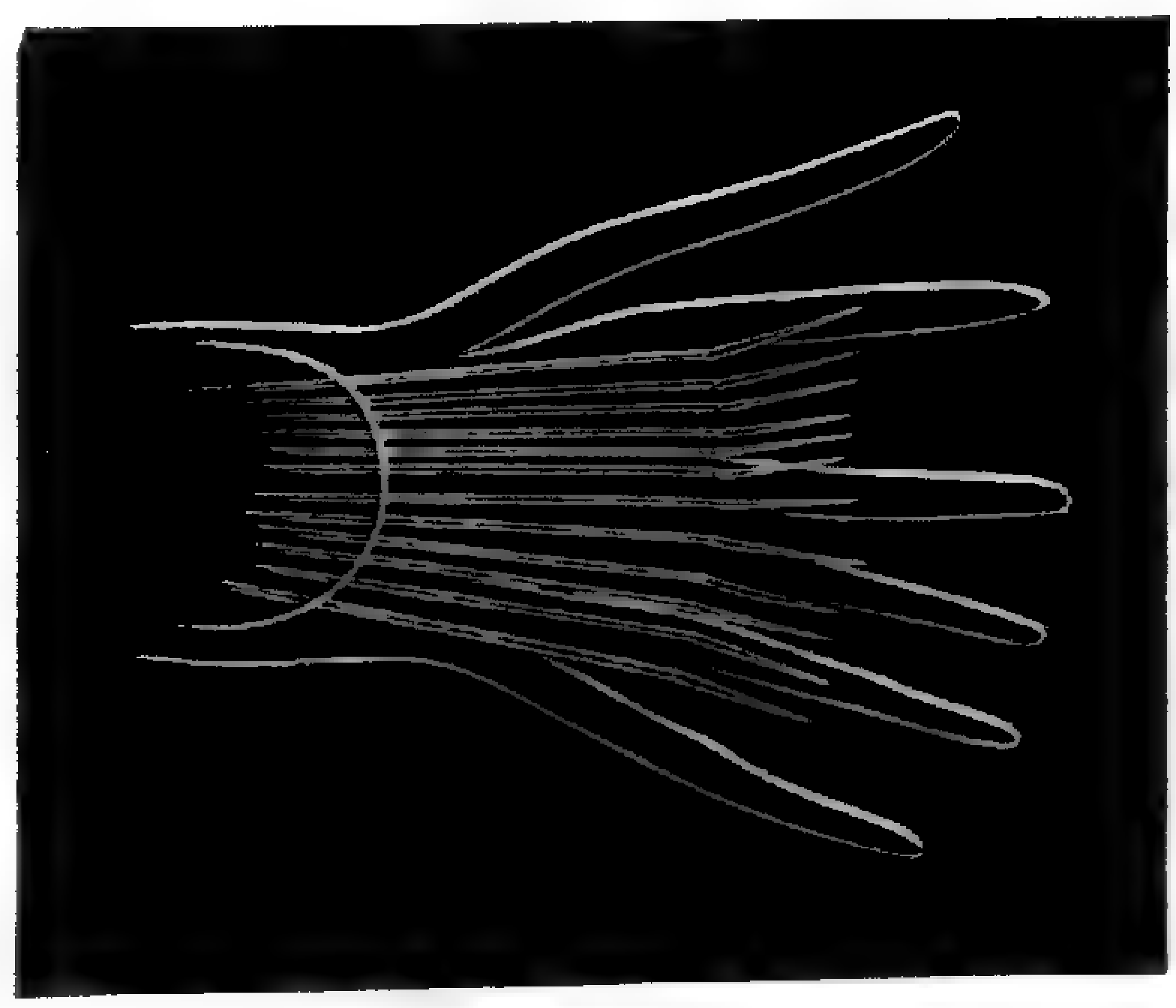

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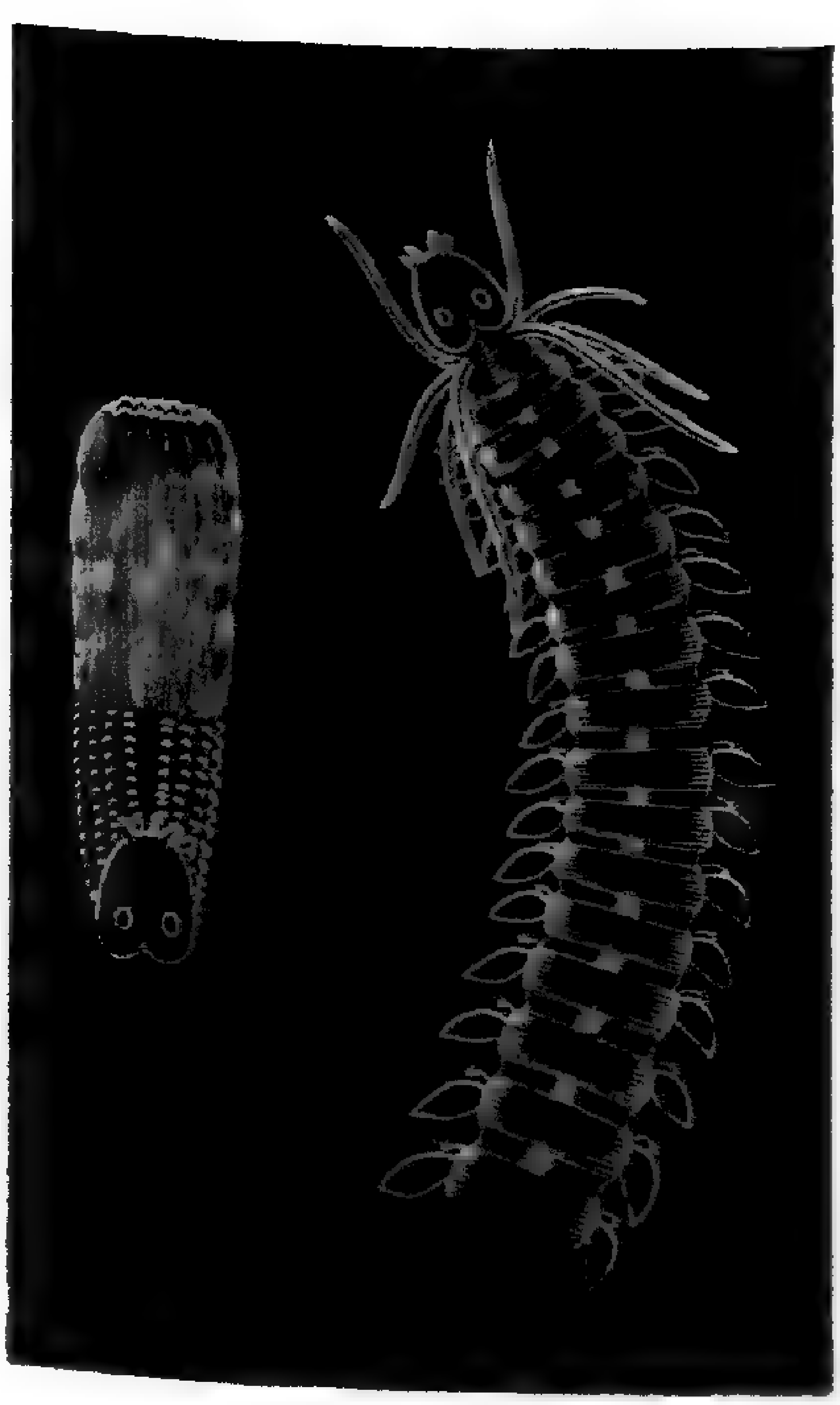

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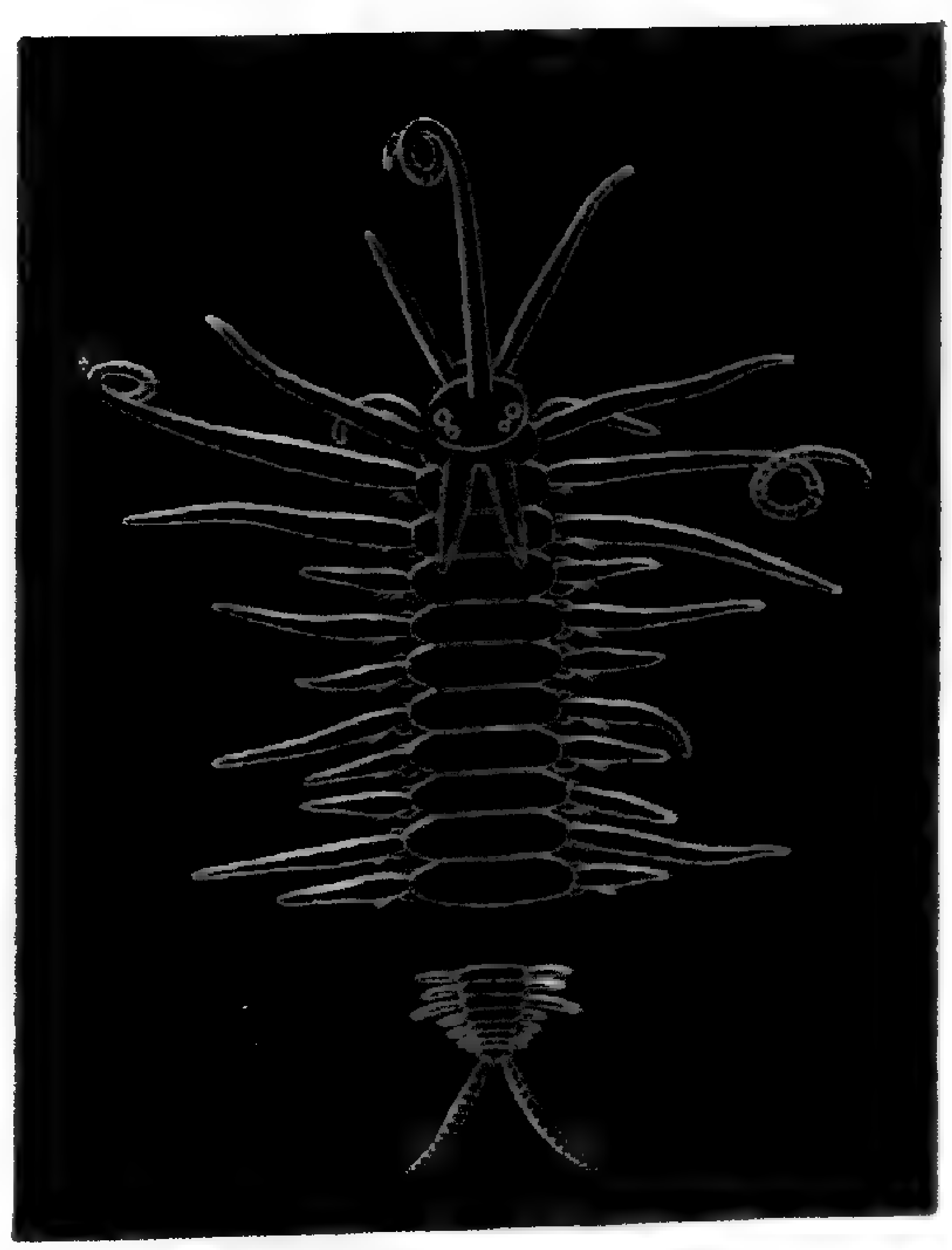

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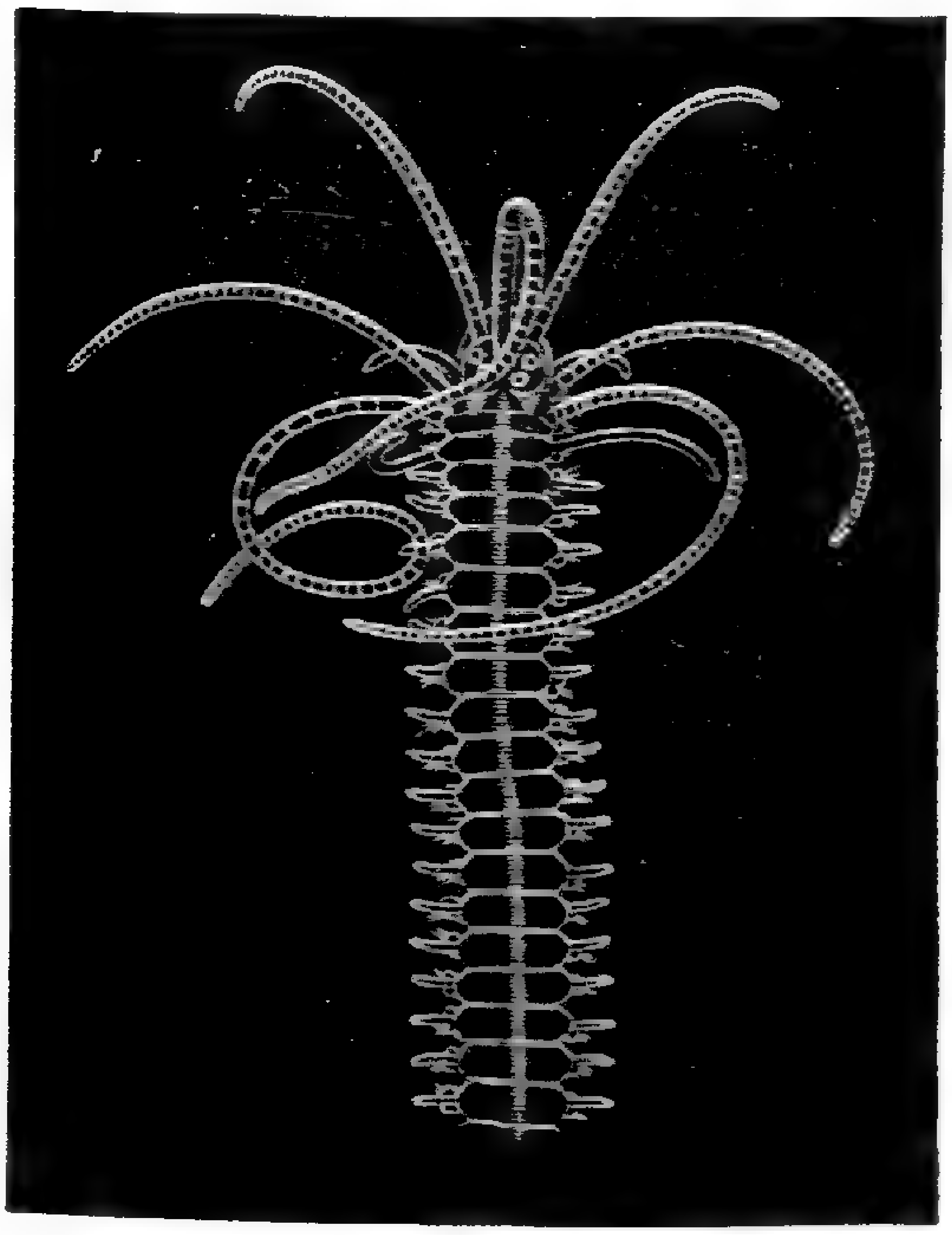

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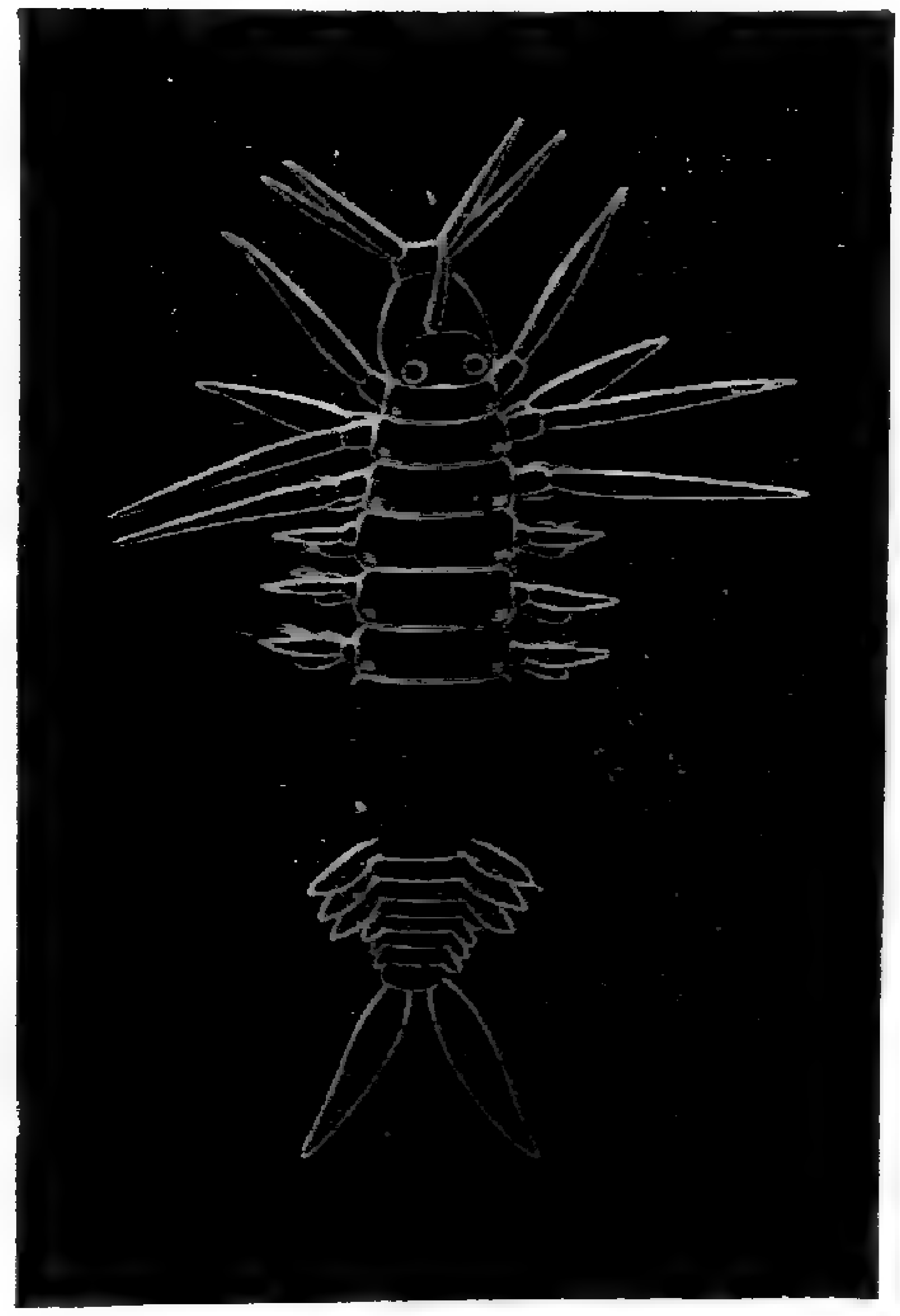

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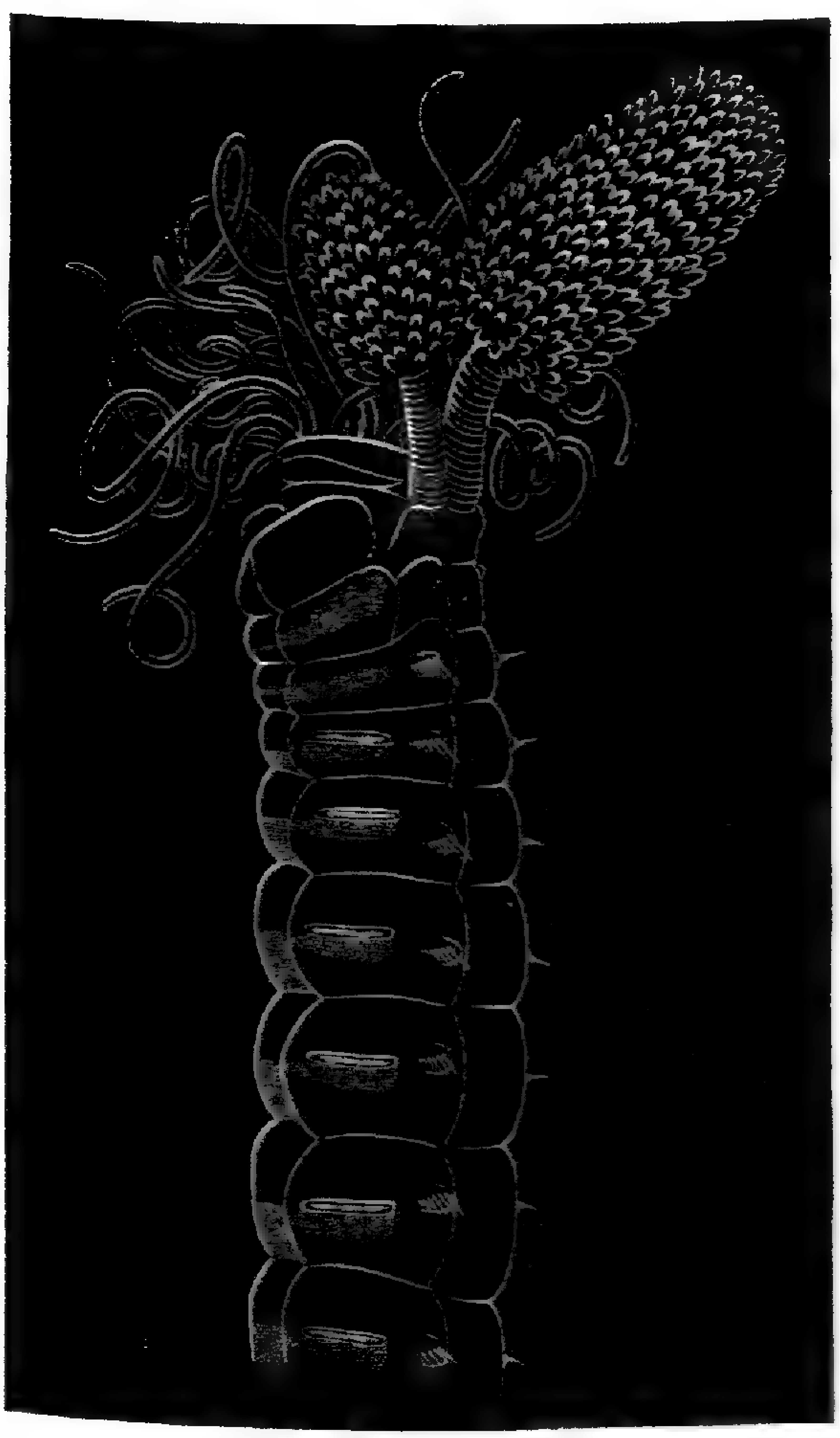

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THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XL.—*On the Polarization of the Zodiacal Light;* by Prof. ARTHUR W. WRIGHT.

FROM the published accounts of observations upon the Zodiacal Light it would seem that few attempts have as yet been made to determine whether or not any portion of the light is polarized, and the results thus far obtained leave the question still undecided. The few notices that can be found in the scientific journals, though uncertain and contradictory, tend to the view that it is either not polarized at all, or that the proportion of polarized light is so small as to render its detection a matter of excessive difficulty. It may be observed that most of the observations giving negative results appear to have been made with Savart's polariscope; but with an instrument which absorbs so large a proportion of the light as a Savart, the amount of polarization necessary to render the bands visible increases very greatly as the light becomes fainter, and especially so as it approaches the limit of visibility. Numerous attempts have been made by the writer to detect traces of polarization with a Savart, but never with the slightest result, excepting that on one especially clear evening, when the zodiacal light was unusually distinct, the bands seemed to be visible by glimpses, on the utmost exertion of visual effort. The observation was so uncertain, however, that it was considered worthless.

Nearly a year ago a series of observations was begun, in the course of which a variety of apparatus was employed, by the use of which it was hoped polarization might be detected, either, as in the Savart, by bands or other variations in the brightness of parts of the field, or as with the double-image prism, the Nicol's prism, or a bundle of glass plates set at the polarizing angle, by a diminution of the brightness of the object itself. None of them, however, gave results of any value. In resuming the study of the subject some months later, the attempt was made to find a combination which should give a large field of view, and which, while absorbing as little light as possible, should indicate the presence of even small proportions of polarized light, by sufficient variations of intensity to render it available with the faintest visible illumination.

A Savart in which the tourmaline was replaced by a Nicol, though possessing almost perfect transparency, was found to give too small a field of view, and bands too faint to render it of any service. Another instrument was constructed on a plan similar to that adopted by Mr. Huggins in observations upon Encke's comet,* by placing a large double-image prism in the end of a tube eighteen inches long, the other end of which had a square aperture a little more than an inch in diameter. The distance was so adjusted that the two images just touched without overlapping. This seemed to promise well, and on using it differences of intensity were perceived which indicated polarization in a plane passing through the sun. Two defects, however, are inherent to this mode of investigation; one, that if the field is not of uniform brightness throughout, the brighter side of one image may be juxtaposed to the fainter side of the other, thus giving rise to false conclusions; another in the unequal sensibility of different parts of the retina. In consequence of this, the one of the images directly viewed seems always the more obscure, and the true relation of their intensities can only be found by indirect vision, the eye being turned to some point in the median line of the images. Although when used with the observance of the necessary conditions, this instrument is capable of giving trustworthy indications, it was soon abandoned for a better.

Among the polariscopic apparatus belonging to the physical cabinet of Yale College, a quartz plate was found, cut perpendicularly to the axis, and exhibiting by polarized light an unusual intensity of color. It is a macle, the body of the plate consisting of left-handed quartz, through which passes somewhat excentrically a band of right-handed quartz, 6·5 millimeters in breadth. This band is not bounded by sharp lines of division on the sides, but by intermediate strips (*b b* in the figures), about two millimeters in breadth, which are of different structure, and are apparently formed by the interleaving of the strata of the two portions at their edges. In the polarizing apparatus these strips simply vary from bright to dark, without

* Phil. Mag., vol. xliii, 1872, p. 382.

marked appearance of color. Placed between two Nicols, the plate has the appearance represented in the accompanying figures, which are drawn of full size. When the corresponding

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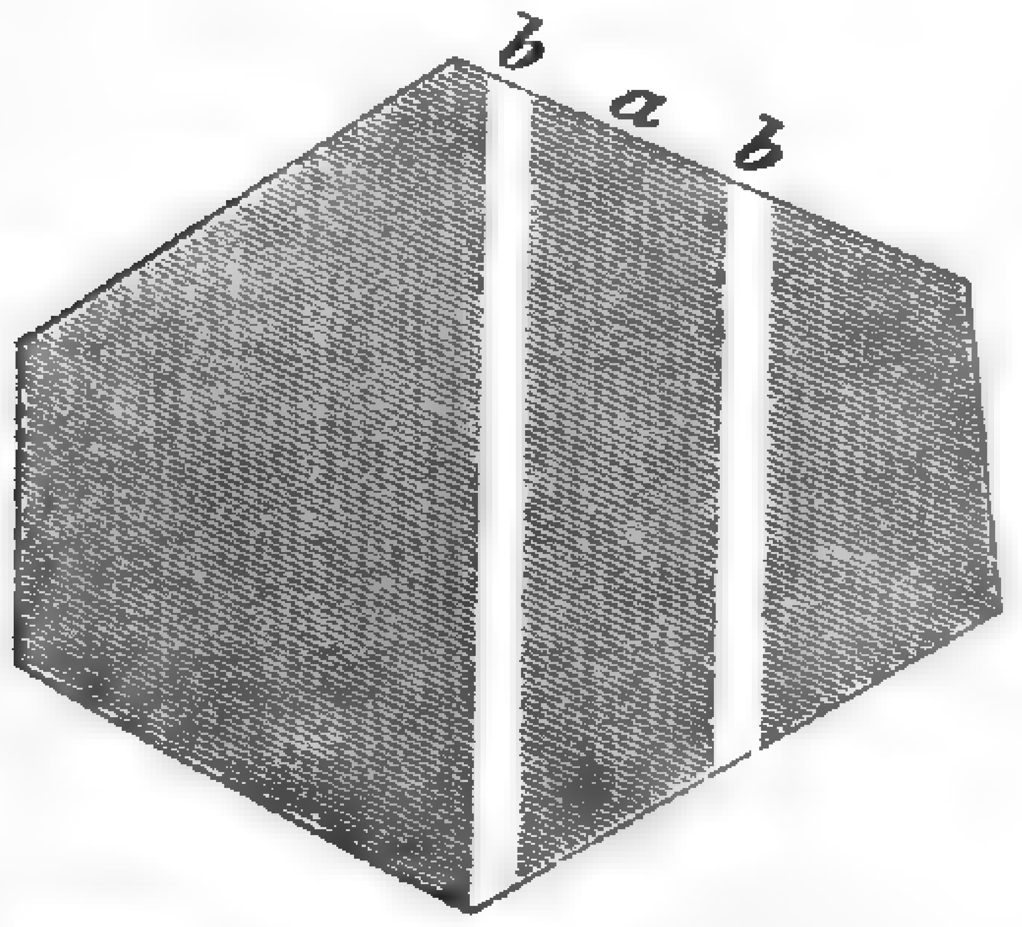

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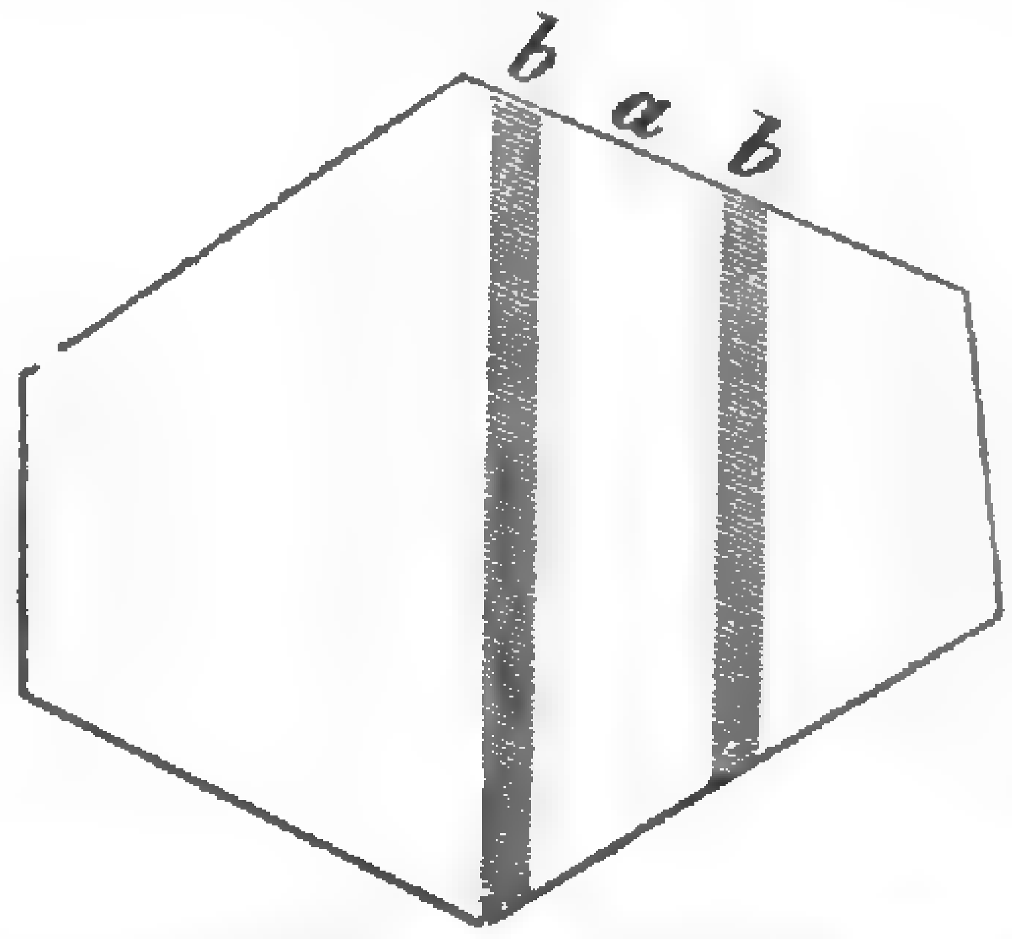


diagonals of the Nicols are parallel, or nearly so, the bands are white upon a deep reddish purple ground, as shown in figure 1; with the Nicols crossed, the bands are dark upon a light greenish yellow background, as represented in figure 2. Turning one of the Nicols 45°, in one direction, the observer sees the central band *a* intensely blue upon a yellow ground; turning in the other direction, a bright yellow upon a dark blue, and intermediate positions give the usual varying tints. Examined with one Nicol and unpolarized light the plate is perfectly colorless, and shows no trace of its heterogeneous structure.

The quartz plate was placed in one end of a tube, large enough to admit its full size very nearly, and eleven inches in length. This was found better than a shorter one, as the bands are most easily seen when not nearer the eye than the limit of distinct vision. In the other end was placed a good sized Nicol, and the tube was provided with a joint so that the latter could be easily turned. Thus mounted, the plate and Nicol form a polariscope of extraordinary sensibility, with faint light far excelling the best Savart, and even with strong light somewhat superior to it. The instrument is especially suited for the detection of small degrees of polarization, and the examination of very faint lights. The occurrence of the narrow strips is peculiarly advantageous, as with very feeble illumination they appear bright upon a dark ground, or the reverse, and are thus more easily seen. The efficiency of the instrument is further increased by the comparatively large field of view, and the perfect transparency of the whole combination.

As a test of its delicacy may be mentioned that when a glass plate is laid upon the window-sill, and the light of the sky in a clear, moonless night, after reflection from it, is viewed through the instrument, both bright and dark bands are easily seen, the former appearing surprisingly luminous in contrast with the darkened field. The plane of polarization is easily determined with it, since when the bright bands appear, as in figure 1, the longer diagonal of the Nicol is in that plane; when the bands are dark, the plane of polarization is parallel to the shorter diagonal.

On the completion of the instrument the first favorable opportunity was improved to test its efficiency upon the zodiacal light. It was almost immediately found to indicate the existence of light polarized in a plane passing through the sun. The bands were fainter than had been expected, and at first were overlooked. More careful attention, however, and the observance of suitable precautions established their presence beyond a doubt. The observations were made in a room in the upper floor of one of the college buildings, the windows of which look toward the southwest, and command a clear view nearly to the horizon. The room during the observations received light only from the sky, which sufficed to render objects dimly visible. After being exposed only to this dim light for fifteen or twenty minutes, the eye became sufficiently sensitive for observation. This was a very necessary precaution, as a moment's exposure to a bright light rendered the eye unfit for delicate discrimination of luminous intensities for a long time. The Nicol of the instrument was now turned round and round, so that no previous knowledge of its position relatively to the bands of the quartz plate might influence the judgment as to their character and position. On looking through the tube at the zodiacal light, and turning the whole instrument slowly round, it was possible to find a position where the bands could be seen, and their nature and direction determined. They could rarely be seen steadily by direct vision, and then only for a few moments, as the excitement and fatigue of the eye consequent upon the straining effort of vision soon rendered the field a confused blur. Allowing the eye to rest a few minutes, also on turning it obliquely, and rapidly directing it to different parts of the field, and especially by suddenly bringing it to focus upon the quartz plate, the bands could be distinctly seen, and their direction fixed with a good degree of certainty. On the clearest nights the brightest bands (*b b*, figure 1), were seen without much difficulty, the broad dark band (*a*) corresponding to an inclination of 45° in the Nicol, less easily, and the dark bands (*b b*, figure 2) by glimpses. After determining, by repeated observations, the angle made by each of the bands with some fixed line, as the axis of the zodiacal light, or a line nearly parallel to it drawn between two known stars, the position of the plane of polarization was found, by means of light from a gas-flame reflected from a sheet of white paper placed in a suitable position, or by observing the position of the Nicol. The reults of the numerous observations of different evenings were entirely concordant, and showed that the plane of polarization passes through the sun, as nearly as it was possible to fix its direction. In no instance when the sky was clear enough to render the bands visible, did their position, as determined by the observations, fail to agree with what would be required by polarization in a plane through the sun. Not the slightest trace of bands was ever seen when the instrument was directed to other portions of the sky.

These observations, for the most part, were made in the ten days preceding new moon in January and February of the present year. During this time there was an unusual number of clear nights, with the atmosphere cold and still. A few good evenings in March and April also were improved in verifying the results previously obtained. The absence of the moon, and the distance of any of the brighter planets and stars from the field of observation, removed all uncertainties from these sources. As the instrument was directed to points from 30 to 40, or even more, degrees from the sun, the polarization could not have proceeded from faint vestiges of twilight. That it did not arise by reflection of the zodiacal light itself in the atmosphere, or from atmospheric impurities, is shown both by its amount and the fact that it was always most easily discernible on the clearest nights.

The next step was to determine what percentage of the light is polarized. The failure of the common apparatus to detect it shows that the proportion is not large, but it must be recollected that for a light so very faint much greater differences of intensity are imperceptible than in cases where the luminous intensity is greater. The determinations were made as follows. A bundle of four pieces of excellent plate-glass was placed vertically at the center of the horizontal divided circle of a Deleuil's goniometer, the telescope of which was replaced by the polariscope used in the preceding observations. The latter was so placed that its axis was perpendicular to the surface of the bundle when the index of the goniometer was at zero. With the instrument thus adjusted no bands are seen when unpolarized light is passed through it, but on turning the glass plates bands become visible corresponding to polarization in a vertical plane. The amount of the light polarized by refraction through four glass plates at different incidences has been calculated by Prof. W. G. Adams* for intervals of 5°, from 10° to 70°, and at 72°. Taking the values given in his table for crown glass ($\mu=1·5$), those for intermediate angles are readily determined by interpolation, or graphically. The latter method was employed, a curve being drawn representing all the values in the table. The results given in the table correspond very well with those obtained by Prof. Pickering,† who verified his values

* Monthly Notices of the Royal Ast. Soc., March 10, 1871, p. 162.

† This Journal, III, vol. 7, p. 102.

experimentally, and showed that the deviation from theory in the case of four plates only becomes perceptible above 65°. As Prof. Pickering used the value $\mu=1.55$, the numbers in his table are slightly greater than those used in constructing the curve, from Prof. Adams's table.

The determinations were made by observation of the percentage necessary to render the bands visible with the same distinctness as in the zodiacal light. A set of experiments was made with light from the clear sky in a moonless night, the instrument being directed to one of the brightest points of the Galaxy, where the light, though less bright than that of the zodiacal light, did not very greatly differ from it in intensity. The glass plates being turned until the bands had the same degree of distinctness as in the previous observations, the mean of several observations gave as the polarizing angle 41°, corresponding to a percentage of 20·5. This value, on account of the inferior brightness of the light compared, is somewhat too large, and may be taken as an upper limit.

To find a lower limit, and, at the same time, an approximate value, light reflected from a nearly white wall with a dead surface was employed. The point observed with the instrument was so chosen as to be equally distant from two gas-flames so placed that the planes through them and the axis of the polariscope were at right angles, thus giving light entirely free from polarization. The flames were now turned down equally so that the field had, as nearly as could be estimated, the same brightness as it had with the zodiacal light. A small scratch upon the quartz plate, which could just be seen by the light of the latter, served as a means of control in adjusting the intensity. The experiments being conducted as before, gave, as the mean of numerous determinations, the angle 36°·6, corresponding to a proportion of 16 per cent, which is probably not far from the true value of the amount sought. Another, in which the light was made perceptibly brighter than that of the zodiacal tract, gave for the angle 28°·5, and a percentage of 9·4, which is certainly too small. We may safely take 15 per cent as near the true value.

The fact of polarization implies that the light is reflected, either wholly or in part, and is thus derived originally from the sun. The latter supposition is fully confirmed by various spectroscopic observations, of M. Liais,* Prof. C. Piazzi-Smyth,† and others, which show that the spectrum is continuous, and not perceptibly different from that of faint sunlight. The writer has also made numerous observations with a spectroscope specially arranged for faint light, of which an account

* Comptes Rendus, Tom. 74, 1872, p. 262.

† Monthly Notices of the Royal Ast. Soc., June, 1872, p. 277.

will be published hereafter, and which lead to the same conclusion. It may be mentioned further that a particular object in these observations was to determine whether any bright lines or bands were present in the spectrum, or whether there is any connection between the zodiacal light and the polar aurora, and the results give, as an answer to the question, a decided negative. This is important here, as excluding from the possible causes of the light the luminosity of gaseous matter, either spontaneous or due to electrical discharge. The supposition that the light is reflected from masses of gas, or from globules of precipitated vapor, is not to be entertained, since, as Zöllner* has shown, such globules in otherwise empty space must evaporate completely, and a gaseous mass would expand until its density became far too small to exert any visible effect upon the rays of light.

We must conclude, then, that the light is reflected from matter in the solid state, that is, from innumerable small bodies revolving about the sun in orbits, of which more lie in the neighborhood of the ecliptic than near any other plane passing through the sun. Although such a cause for the zodiacal light has often been assumed as probable, no satisfactory proof of it has hitherto been found, and the establishment of the fact of polarization was necessary to its confirmation, since spectroscopic appearances alone leave it uncertain whether the matter is not self-luminous.

If these meteroids, as there is no good reason to doubt, are similar in their character to those which have fallen upon the earth, they must be either metallic bodies, chiefly of iron, or stony masses, with more or less crystalline structure, and irregular surfaces. If we accept Zöllner's conclusion that the gases of the atmosphere must extend throughout the solar system, though in an extremely tenuous condition in space, the oxidation of the metallic meteroids would be merely a question of time. They would thus become capable of rendering the light reflected from them plane-polarized, and the same effect would in any case be produced by those of the stony character.

In order to ascertain whether the proportion of polarized light actually observed approached in any degree what might be expected from stony or earthy masses of a semi-crystalline character, with a granular structure, and surfaces more or less rough, a large number of substances possessing these characteristics was subjected to examination with a polarimeter. For this purpose the apparatus already described was employed, there being added to it a support for the object, with a horizon-

* "Ueber die Natur der Cometen," p. 79, et seq. Abstract in this Journal, III, vol. iii, p. 476.

tal circle for determining the azimuths in placing the object and the light. The substances examined had approximately plane surfaces, which were placed vertically, and so that the normal, at the point observed, bisected the angle between the lines from it to the eye and the illuminating flame. The light being thus polarized in a horizontal plane, was depolarized, that is, compensated, by turning the glass plates through the necessary angle, the percentage corresponding to which was immediately found by means of the curve.

If we suppose a line drawn from the place of observation to a point in the zodiacal light, and another drawn from the sun to this at its nearest point, the two lines would meet at right angles, and a surface at the point of intersection must be so placed as to have an incidence of 45° in order to send the reflected light to the eye of the observer. We may in general assume that there would be as many meteoroids on the nearer side of the line from the sun as on the other. Those on the more remote side, while presenting a larger illuminated surface, would reflect the light at a smaller angle, and therefore polarize a smaller amount of it. Those on the earthward side would send less light to the earth, but polarize a larger proportion of it. The differences would so nearly complement one another that we may take their united effect as equivalent to that of a body placed at the point of intersection mentioned above. For this reason the objects tested were so placed that the angles of incidence and reflection were 45°.

Some of the substances, and the percentages obtained, were as follows Porphyry, ground smooth, but not polished, 35 per cent; another surface thickly covered with accumulated dust, 15·5; dark blue shale, 25·7; syenite, coarsely crystalline and rough, 16·4; gneiss, rather fine-grained, 8·3; granite, fine-grained, 11·8; red jasper, rough broken surface, 23·5; sandstone, 12·1; brick, rough fragment, 8·1; the same, smooth surface, 11·3; red Wedgewood ware, unglazed, 14·2; indurated clay, light brown, 11; mortar, whitewashed surface, 12·1; the same, rough side, 6; white chalk, cut plane, 2. A fragment of the great meteorite of Pultusk, which the writer owes to the kindness of Prof. O. C. Marsh, gave from a broken surface 11·7, from the blackened surface, 36 per cent of polarized light. It is of the stony class, and of a light bluish gray color.

The results show that from surfaces of this nature the light reflected has in general but a low degree of polarization, not greatly different, in an average, from that found in the zodiacal light. Although no certain conclusions can be drawn from experiments like these, their results are not inconsistent with the supposition in reference to which they were made, but so far as they go, tend to confirm it. The results of the investigation may be summarized as follows:

1. The zodiacal light is polarized in a plane passing through the sun.

2. The amount of polarization is, with a high degree of probability, as much as 15 per cent, but can hardly be as much as 20 per cent.

3. The spectrum of the light is not perceptibly different from that of sunlight except in intensity.

4. The light is derived from the sun, and is reflected from solid matter.

5. This solid matter consists of small bodies (meteoroids) revolving about the sun in orbits crowded together toward the ecliptic.

Yale College, April 6, 1874.

Art. XLI.—*The "Great Conglomerate" on New River, West Virginia;* by Wm. M. Fontaine.

A few miles below the Falls of the Kanawha, a massive white sandstone rises from beneath the lowest strata of the Lower Coal series. This rock, over which the river runs at the Falls, is shown in the hills along New River for a distance of nearly forty miles. Continuing to rise to the east, it discloses, beneath, a great formation of sandstones, containing important beds of coal. This formation is well known as differing strikingly, both in its fragmental rocks and coals, from the overlying lower coal. There are different opinions, however, as to its true place in the geological series. Prof. Wm. B. Rogers, the only one who ever examined it carefully in connection with the general geology of the State, was inclined to consider this lowest coal field as the equivalent of the "Great Conglomerate," here much expanded.

Others hold that it is merely a great development of the lower coals. Again, to the east, this series of coals is underlaid by the enormously expanded Sub-carboniferous group. As this latter contains in this region important coals also, an additional element of doubt is introduced.

The recent active exploration of the New River coals, caused by the opening of the Ches. & O. R. R., renders the present a favorable time for the study of this region. A recent visit to a point where this series of rocks is best exposed has put me in possession of some data which may be of interest.

I think that we cannot fully understand the peculiar features of the New River coals, unless we examine the nature of the accompanying formations in this section. I may therefore be permitted to give here some of the scanty store of facts obtained concerning the overlying and underlying formations. I would state in this place that the fourfold division of the strata of the Appalachian coal field made in the Pennsylvania reports, is strikingly applicable to all parts of this field in West Virginia, and hence I shall use the terms employed by H. D. Rogers, in that work, denoting such a division.

The Ohio River, at the mouth of the Kanawha, flows a little to the west of the center of the great Appalachian coal basin. A line drawn along the course of the Kanawha and New Rivers would pass nearly at right angles across the outcropping edges of all the strata embraced in this basin. These rivers trench the soil deeply, and afford excellent natural sections. If, then, we enter the basin from this point on the Ohio, and proceed eastward along this line, we shall be enabled to get a connected view of the several formations in this portion of West Virginia. Prof. Wm. B. Rogers has determined the dip of the strata along this line. It is toward the center of the basin, or to the northwest. The inclination is greatest on New River, diminishing gradually toward the Ohio. As we approach this river it becomes hardly perceptible, and, a short distance east of it, is reversed, owing to its position in the basin.

The steeper dips on the east vary from 30′–100′ to the mile, owing to the occurrence of broad anticlinals. The normal amount may be taken at 80′ (80 feet) to the mile.

The strata shown at the mouth of the Kanawha belong to the Upper Coal series. Near Point Pleasant a bed of coal appears, 18′ above high water mark, and 2¾ feet thick. This Prof. Rogers identifies as the Pittsburg. While this coal differs greatly from its exposures farther north, the accompanying strata have changed to an equal degree. The thickness of the Upper Coal series is here greatly diminished. The well-developed limestones of the north are now calcareous shales; the thick and numerous beds of coal are reduced to one, or at most two; and the massive formation of sandstones and shales, forming, in the north of the State, "The Upper Barren Measures," are lacking. Up the Kanawha, the gentle inclination of the strata causes the Pittsburg coal to crop out near the mouth of the Pocatalico River, having here increased to a thickness of 5′. A second thin bed is here shown. No measurements have been made of the thickness of the Upper Coal series. For the sake of comparison, I add a description of the same strata in the north of the State, as determined, near Morgantown, by Prof. Rogers and Dr. J. J. Stevenson. In this section the series contains four beds of coal, with 27′ of pure bituminous matter, the Pittsburg alone having a thickness of 11½′ of pure coal, with 2½′ of shale. Besides these there occur, higher up, two other seams, which are locally of importance. The former are contained in 300′ of fragmental rocks, above which occurs a great (unmeasured) thickness of barren strata.

The topography of the country near the mouth of the Kanawha discloses beautifully the soft and yielding nature of the strata. The banks of the stream are low, the flats wide, and the hills softly rounded.

Passing up stream to the east of the outcrop of the Pittsburg coal, we enter the barren upper portion of the Lower Coal series, which Rogers calls the "Lower Barren Measures." This, unlike the overlying series, shows no diminution in thickness, but is even thicker here than in the north, evidently gaining its increase of matter in the lower beds. No measurements of the whole have been made, but we are justified in this conclusion from the following facts: Including its base, the "Mahoning sandstone," it is exposed for a distance of more than 15 miles along the river. The Mahoning has been measured by Rogers above Charleston, and he finds it 140′. In the north of the State, near Morgantown, the Mahoning measures 75′, according to Stevenson, who gives 450′ for the thickness of the entire series here. The average dip on the Kanawha cannot fail to give a much greater thickness. In this formation we find the first of a series, which reach, in this region, a marked development, as compared with their exposures to the north.

The massive strata of this series, especially toward its base, produce a great change in the features of the country. The hills close in upon the river, and rise higher and more abruptly, disclosing massive ledges of rock in their river slopes. Indeed, from this point, the course of the stream becomes more and more gorge-like, until, on New River, we have the formation of a true cañon.

While the Lower Barren Measures seem to thicken to the south, from the Pennsylvania line, they appear to undergo a corresponding considerable development to the northeast, as we shall see is the case with the underlying older formations. They continue to a point some six miles above Charleston, where the upper strata of the lower coals make their appearance. This latter series, on the Kanawha, presents the strongest possible contrast with its character in the north, near Morgantown. In thickness, number of coal beds, and character of deposits, it is just the reverse of the Upper Coal series on the Kanawha. For comparison, we may take the section at Morgantown. We find here, according to Rogers & Stevenson, 200′ of fragmental rocks, in which the shales aggregate 140′. The 60′ of sandstones are mostly flaggy and argillaceous. The thickest single sandstone lies near the base, and is only 25′ thick. The thickest shale is 30′–40′. Only 13′ of coal are found in five beds.

The thickness of the series on the Kanawha is, by those best acquainted with the field, taken to be 950′. Rogers calls attention to the great diminution in the amount of shales and argillaceous matter in this portion of the field. As a consequence, we find the several strata more massive and of greater thickness. To illustrate this, we may note the fact that Rogers found the uppermost sandstone of the series, which lies close under the Mahoning, to be 215′ thick, while the next one below this has the thickness of 200′. The only important shale of the series lies under these sandstones, having the thickness of 40′, but it is much mingled with inter-stratifications of flaggy sandstone. The lowest beds of the series are coarse, heavy sandstones, where they overlie the succeeding formation below the Falls, but this is apparently not the case farther to the eastward, on New River, where they have been principally removed by denudation.

To give the reader some idea of the number and thickness of the coal seams in the Lower Coal series on the Kanawha, I append the following measurements, taken near the mouth of Paint Creek. This point being some distance west of the east outcrops of the base of this series, the initial plane is considerably above this base, and hence the lowest rocks are not given here. To complete the section, we should add a portion of the strata measured at Sewell Mountain on New River. Even then there exists an unknown interval, there being no means of connecting the two measurements. The coal seams on Paint Creek occur in the richest portion of the Kanawha coal field. These measurements are the most extended that have been made in this section. For the Paint Creek section, and that at Sewell Mountain, along with other valuable information, I am indebted to M. F. Maury, Jr., M.E., F.G.S., whose acquaintance with this region renders him the best authority in matters connected with it. The measurements on Paint Creek commenced at a point 40′ above the level of the Kanawha. The following is the section. Commencing at the bottom, the first bed occurs 12′ 6″ above the initial point; while, above this, the various seams occur at the intervals given in the left hand column:

Top of Hill.		Thickness.
283′	Seam	Not opened.
34′	"	2′
21′ 5″	"	3′ 6″
10′ 6″	Flint ledge	
10′ 6″	Seam	4′
66′	"	4′
42′ 6″	"	11′ 4″
53′	"	3′ 6
33′	"	6′
42′ 8″	"	Not opened.

Top of Hill.		Thickness.
17′ 6″	Seam	2′ 6″
22′ 2″	"	Not opened.
38′ 3″	"	"
9′	"	"
58′	"	"
35′	"	"
79′	"	2′
15′	"	2′
21′	"	3′ 6″
29′	"	2′
11′	"	3′
12′ 6″	"	2′ 6″
40′ above the Kanawha, and commencement of section.		

We thus have, in a hill 984′ high, 51′ 10″ of coal, with seven seams not opened. These measurements extend up into the Lower Barren group. The interval of 283′, with the coal seam at its termination, occurs in this series. The stratum called the "Black Flint Ledge," in this section, is a remarkable rock, and deserves special mention. It is usually about 7′ thick. In many places it is, for a portion of its thickness, a true flint. Usually, however, it is a dark hornstone. It is a very persistent stratum, and may be recognized at a glance over wide spaces. It serves as a valuable mark for the determination of the upper limit of the Lower Coals on the Kanawha. It is, however, a short distance below the Mahoning sandstone, the true upper boundary. Its equivalent in the north of the State is a black bituminous slate, crowded with marine organisms, among which Dr. Stevenson found species of *Yoldia*, *Nucula*, *Macrocheilus*, *Productus*, *Athyris*, *Bellerophon* and *Phillipsia*. Extending into Ohio, its wide prevalence gives indication of an extensive change in the conditions then prevalent in the basin. It well deserves a careful examination under the microscope. A rough examination made by myself gave indications that this rock has been produced by the aid of minute organisms. The coloring matter is grouped in cellular forms like the Desmids of the Devonian hornstone. In the north of the State numerous marine shells are found in some of the overlying strata of the barren group, showing a continuance of marine conditions for a considerable period.

Some three miles below the Falls, the northwest dip continuing without change, a new series of rocks make their appearance. This is the New River system of coals, which, for the sake of distinction, we may call the Conglomerate series.

As has been stated at the commencement of this article, the conglomerate series is introduced by a massive white sandstone. This differs strikingly from the overlying strata. It is a white, highly siliceous, coarse-grained sandstone, often conglomeritic in texture. It is easily distinguished also by its massive bedding and resistance to erosion. As we ascend New River from the Falls, this rock ascends in the hills with about the same dip as the Lower Coal strata. At Boyer's Ferry or Sewell Station, near Big Sewell Mountain, it attains its maximum height of 900′. This point is more than thirty miles above the Falls, and long before reaching it this stratum would have been carried above the plane of erosion, but for the occurrence of flat anticlinals, which occasionally bring down the strata to a certain extent. These anticlinals also keep below the plane of erosion the Lower Coals, and cause them to occupy entirely an expanse of more than thirty miles of country between Charleston and the Falls. Prof. Rogers determined two such in the Kanawha region. At Sewell Station the massive sandstone still bears on its back the Lower Coal rocks, but they are greatly eroded, and show only two, or at most three, beds of coal.

As before stated, the rise of the white sandstone discloses underneath a great series of strata which conform to it in dip, and contain several important beds of coal. These strata, mainly sandstones, are unlike the massive upper ledge, and resemble strongly the rocks of the Lower Coal series. They are argillaceous, and contain a considerable amount of oxide of iron. This causes them to be comparatively thin-bedded, and to assume a dull brown color on weathering. This system is best disclosed at Sewell Station, where a section of more than 900′ may be seen.

Between the Falls and this station, New River flows in a deep gorge, which deepens as we ascend the stream. This cañon is produced entirely by the presence of the massive sandstone in the hills, and its depth depends on the height to which this rock rises. So soon as the channel had attained some depth in this stratum, the stream would be confined within unyielding walls, and compelled to exert its entire erosive power within narrow limits. No amount of rainfall entering from the sides could destroy the perpendicularity of the banks. The massive sandstone also protected the weaker formations beneath it, and at the same time prevented the more fragile strata of the Lower Coals above it from being entirely swept away. In consequence of these conditions, the massive rock determines the general plane of the country, the relief features of which, in the New River region of West Virginia, are carved out of the Lower Coal rocks. With reference to the level of the river, this plane of the country descends from a point east of Big Sewell as we pass down stream, until at the mouth of New River the two coincide, when the massive ledge sinks to the water level and begins to disappear. Here, of course, the cañon features are lost.

Hence, anywhere in the gorge of the river, the following topographical features are presented: After climbing the precipitous walls which closely hedge in the river, and which are composed of the Conglomerate series, one is surprised to find, on surmounting the topmost rim, that he has only attained the general level of the country. The river is flowing far below him, while around him, and in the distance, rise softly rounded hills, plainly showing that he has passed into a series of rocks of a physical character very different from those he has just left behind.

The section exposed at Sewell Station does not reach to the base of the Conglomerate series, for its lowest strata make their first appearance some distance to the east of this point. The following is a general description of the strata here exposed. The lowest rock visible, a short distance east of the station, is a reddish shade. Over this lie some 150′ of a very argillaceous sandstone, gray when fresh, but weathering reddish-brown. These rocks are very flaggy at their base, showing innumerable laminæ less than 1″ in thickness. They are less argillaceous and thicker-bedded toward the top. The strata overlying them for some 200′ I could not examine in detail, since they are not well exposed. They are almost entirely sandstones, gray in color, and less argillaceous than those below. Two thin beds of shale, quite fine in texture, are partially disclosed. One is black and quite bituminous; the other, overlying it, is blue. Higher up, the sandstones again become quite argillaceous, and very flaggy. In this portion the more important seams of coal occur. These, again, lose their argillaceous character, and pass into the massive ledge which forms the closing feature in the series. The coals all occur toward the middle and top of the series.

[To be continued.]

ART. XLII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXVIII.—*On the Use of Potassium Dichromate in Ultimate Organic Analysis;* by S. W. JOHNSON.

COMBUSTION of organic bodies by aid of cupric oxide and a stream of oxygen gas, or by the latter alone, as in Warren's method, leaves little to be desired when a series of analyses are to be executed of substances free from alkali or alkali-earth-metals. For occasional use, or for bodies containing the metals just named, recourse is most conveniently had to lead chromate, either alone or with admixture of potassium dichromate as Liebig suggested. The preparation of lead chromate in a state of purity and fine pulverization is, however, very tedious and laborious. I find that potassium dichromate mixed in suitable proportion with some infusible and indifferent body may be substituted for lead chromate, without detriment to the result, and with decided advantage in regard to cheapness and convenience.

My friend Mr. Geo. W. Hawes, on my suggestion, has made the experiments described below, and I take this occasion to express my thanks to him for the care and skill with which he has worked out the results.

Potassium dichromate has nearly all the properties needful for an oxidant in organic analysis. It is found in commerce in a state of tolerable purity, and is readily and perfectly freed from objectionable admixtures by recrystallization and fusion at a low red heat. After fusion, it may be reduced to a moderately, but sufficiently fine powder with the greatest ease. When heated to bright redness, it gives off oxygen gas. Its only imperfection lies in its fluidity at the temperature suitable for combustion.

Ordinary kaolin, or fire clay, is perhaps generally the cheapest material for diluting the potassium dichromate. The clay used in these experiments was nearly white and very fine, and was procured at a stove store in New Haven. Clay from the laboratory stock was found useless from containing anthracite dust, it having been kept for a long time poorly covered in our furnace room.

The clean sifted clay, placed in a crucible, was first strongly ignited for half an hour in a charcoal fire. It was then mixed intimately with about eight per cent of commercial potassium dichromate, by evaporating upon it a solution of the salt to dryness. This mixture was ignited for an hour in a clean covered crucible. This preliminary treatment was intended to remove all hydrogen and carbon from the clay. Doubtless the first ignition might be dispensed with. The prepared clay was put while hot into clean well stopped bottles.

A quantity of potassium dichromate was recrystallized, fused, pulverized, and also bottled while hot.

A series of mixtures were next made of the prepared clay and dichromate, and exposed to the heat of an Erlenmeyer gas furnace, in order to ascertain what proportions would yield a mixture that should contain as much dichromate as possible, and yet not flow or otherwise disturb the process of combustion.

It was found that, with the kaolin employed, a mixture containing forty per cent of the dichromate was entirely suitable for the analyses of substances whose combustion presents no special difficulty. With thirty per cent of dichromate, the ignited mass was highly porous after cooling; but with forty per cent it was quite solid when cold. With fifty per cent of dichromate, the mixture fairly fused to a pasty mass. With sixty per cent, it fused, and although it was not fluid enough to run, it effervesced strongly, and here and there closed the tube, but finally fused down, leaving a channel. With seventy per cent of dichromate, the ignited mass was thin enough to flow in the tube.

It thus appeared that a mixture of three parts of prepared kaolin with two parts of fused and pulverized potassium dichromate has all the qualities adapted for ordinary combustions; and this we have employed in most cases. Only in combustions of graphite has the proportion of dichromate been increased to fifty-five per cent.

This mixture is more hygroscopic than fused and pulverized lead chromate, as might be anticipated from its greater fineness and porosity. Twenty grams of it exposed to rather dry air of 65° Fah., side by side with twenty-five grams of lead chromate, gained in three minutes, nothing, in five minutes $\frac{2}{10}$ mgr., in ten minutes $\frac{1}{2}$ mgr., in thirty minutes $\frac{8}{10}$ mgr., in one hour 1 mgr., and remained thereafter unchanged during twenty-four hours; the lead chromate suffered no change. In a second trial, twenty grams of the mixture of another preparation were placed beside twenty grams of lead chromate under a bell glass, above a moist sponge. After $3\frac{1}{2}$ hours exposure, the mixture had gained 0·045 grams; the lead chromate but 0·0045 grams. The absorption of moisture is, however, not rapid enough to seriously vitiate the results of analysis, when Bunsen's plan of mixing in the tube is adopted.

The amount of potassium dichromate contained in the charge of an ordinary combustion tube is fifteen to twenty grams. These quantities are capable of yielding 2·4 to 3·2 grams of oxygen in the combustion of an organic body, on the supposition that the chromium all remains as chromic oxide. By employing narrow tubes, these quantities might be safely reduced somewhat without detriment, if, as is probable, the silica of the kaolin would prevent the formation of potassium carbonate.

But, using the largest amount of potassium dichromate, viz: twenty grams, a kilo. of the commercial salt, costing here at most, seventy cents, serves for making fifty analyses.

In a preliminary blank combustion with the mixture of forty per cent dichromate, oxygen gas was given off continuously for twenty minutes; the potash bulb lost 0·019 grams, which was compensated by the exactly equal gain of the appended soda-lime and calcium chloride tube. The moisture gained by the calcium chloride next the combustion tube was 0·0015 grams.

The results of actual combustions are tabulated below:

	Cane sugar. 0·2822 grams. Burned with 40% mixture.	Calculated.	Equisetum hyemale. Burned with 40% mixt.	Burned with Lead chromate.	Cast iron. 4 grams. Burned with 40% mixt.	Burned with 55% mixt.	Burned with Lead chromate.
C	42·12	42·10	41·85	41·92	3·15	3·29	3·25–3·30
H	6·55	6·43	5·92	6·01			

The cast iron was from a sample of fine borings that had been repeatedly analyzed with results varying between 3·25 and 3·30. It contained both graphite and combined carbon. It was first treated with cupric chloride, and the carbon was collected on an asbestus filter. The analysis yielding 3·15 per cent was the first attempt of Mr. Hawes to estimate carbon in iron, and the deficiency may perhaps not be due to the small proportion of potassium dichromate (forty per cent) in the mixture. In the next analysis, the carbon was rubbed up with a mixture containing fifty-five per cent of dichromate; but the mortar was rinsed with the forty per cent mixture. The combustions usually occupied forty-five minutes. In one case, aspiration, lasting fifteen minutes, sufficed to displace all oxygen from the bulbs; the flow of air (purified by streaming first through a soda-lime and calcium chloride tube), being resumed for an hour, occasioned no change in the weighed calcium chloride tube, nor in the joint weight of the potash bulbs and their appendage.

I believe these results justify calling the attention of chemists to the use of the mixture I have indicated, as a cheap, convenient and efficient substitute for all the solid agents hitherto employed in this branch of organic analysis, cupric oxide alone excepted, and that only when used in conjunction with oxygen gas.

Art. XLIII.—*On Helderberg Rocks in New Hampshire;* by C. H. Hitchcock.

The discovery of Helderberg fossils in New Hampshire was announced as follows in a telegram addressed to Dr. T. R. Crosby, President of the Dartmouth Scientific Association: "Littleton, N. H., Sept. 28, 1870: No longer call New Hampshire Azoic. Silurian fossils discovered to-day." The dispatch was read the same evening to the Association, at a regular meeting. Not long afterward, E. Billings of Montreal reported upon the specimens.* The corals appeared to be *Favosites basaltica* and *Zaphrentis*, probably the same with those occurring near Lake Memphremagog in Canada. The crinoids were all small. Mr. Billings found nothing that would localize the hori-

* This Jour., III, vol. ii, p. 148.

zon more definitely than the general term of Helderberg. The Owl's Head locality, fifty-five miles distant from Littleton, in Canada, has furnished the characteristic *Atrypa reticularis* and other species of the Upper Helderberg, enabling the Canadian geologists to represent upon their maps several narrow strips of the Upper Helderberg limestone. And it has been natural to suppose that these two terranes would prove to be of the same age, particularly since there is considerable similarity between the rocks enclosing the fossils, at both localities.

An allied rock has long been known at Bernardston, Mass. It was first described by my father in the Massachusetts Report of 1833, with a drawing of the crinoidal stems. Quite recently, Professor Dana has described the locality and the adjacent strata,* deducing important generalizations from his observations. The Memphremagog and Bernardston deposits lie upon the opposite sides of the same formation—the calciferous mica schist group of the Vermont Report, and Upper Silurian (supposed Niagara) of Sir W. E. Logan's report—and separated by a distance of 165 miles. The mica schist is probably an older formation than the Helderberg, lying in a trough of clay slates, the latter constituting the floor of the fossiliferous beds. These slates may be Lower Silurian or Cambrian, judging from general considerations. No fossils yet appear in them. The calcareous schists carry a few obscure crinoidal fragments at Derby, Vt., which are of no value in the identification of strata.

At first sight, one would declare that there is no similarity between the Littleton and Bernardston rocks. After considerable study of both localities, I find a few points of resemblance, perhaps as much as we have a right to expect in synchronous deposits more than a hundred miles apart. In our studies, we often look for exact resemblances in remote localities. Perhaps it is better that the connecting tie be discovered with difficulty, in which case the conclusions may be more surely established. The surroundings at Littleton are different from those at Bernardston. The series rests upon a chlorite rock † or hard green hydro-mica schists, close by gneiss, and a whitish soapy schist at Littleton. At Bernardston, the underlying as well as the overlying rock is quartzite, and in the neighborhood are the mica and staurolite schists denominated in my report as the "Coös group." Professor Dana thinks it clear that the Massachusetts Helderberg and the Coös group, as defined by me in Reports of 1869 and 1870, are, "if correctly traced out," identical.

In order to afford data for the proper discussion of the question of the age of these Coös and Helderberg strata, I propose

* This Jour., III, vol. vi, p. 339.

† The "chlorite rock" of this paper may be the same with the diabase found by Professor Dana near New Haven. I have not had time to review the result of analysis of the feldspar. It may contain some lime.

to describe as carefully as possible the details of the distribution of the Helderberg rocks in Littleton and the surrounding towns. We must, however, first describe a small geological map of the Ammonoosuc region.

The following are the groups of strata indicated upon the map, in the supposed order of their age: 1, Porphyritic gneiss; 2, Bethlehem gneiss; 3, Gneiss; 4, Lisbon group; 5, Lyman group; 6, Clay slate; 7, Coös group; 8, Swift Water series; 9, Helderberg rocks.

These designations represent distinct formations. In some cases a lithological name is used for convenience, chiefly that the attention of geologists may not be diverted by a strange terminology. It is not pretended that every layer of the porphyritic gneiss or clay slate is uniformly and absolutely porphyritic or a distinct argillaceous slate; but that these terms represent great thicknesses of associated strata, characterized by the predominance of the lithological varieties mentioned. Other kinds of rock are associated with them, the two series forming two great systems, formed in two distinct periods. The use of geographical names for the other groups of strata will prevent any geologist from misunderstanding what is meant to be signified. The map assumes that this area is occupied by eight or nine entirely distinct systems of strata.

Three new geographical designations appear on this map for the first time, viz., Lisbon, Lyman and Swift Water. The terms Bethlehem and Coös have been defined in my New Hampshire Annual Reports. The Lisbon and Lyman groups are the two main divisions of what in my last report is termed *Huronian*. At first I called it the Metamorphic Quebec group, after Logan.* Recent papers by Credner, Macfarlane and Hunt have recalled to my mind a conversation with Prof. H. D. Rogers in 1858, and the statement of his Pennsylvania Report concerning the southward extension of these rocks into the Middle States. He then expressed the belief that the semi-Azoic groups of Pennsylvania, etc., were equivalent to the rocks recently denominated Huronian by Logan. Inasmuch as his opinion concerning the same rocks in New England cannot stand, and the "semi-Azoic" strata seem to be of the same age, from Quebec to Georgia, it may be proper to use the name Huronian for them throughout, in consequence of his suggestion, which was stated also in his Pennsylvania Report. It will be observed that the Huronian of New Hampshire is a two-fold series. There is a third member which in my forthcoming report will be distinguished from the Lyman group, viz: the auriferous conglomerate. This triple division does not seem to correspond exactly with the Levis, Lauzon and Sillery of

* First and Second New Hampshire Reports.

LITTLETON
LISBON
LYMAN
BATH
CONNECTICUT RIVER
MANN'S HILL
FACTORY VILLAGE
LITTLETON
EUSTIS HILL
BLUEBERRY MT.
STREETER POND
BALD HILL
NORTH LISBON
PARKER HILL
PINE HILL
LISBON
UPPER VILLAGE
LOWER VILLAGE
WOODVILLE
LANDAFF
EXPLANATION.
SWIFT WATER GROUP.
PORPHYRITIC GNEISS.
BETHLEHEM. "
HELDERBERG.
CLAY STATE.
LISBON GROUP.
LYMAN "
COÖS "
GNEISS.
SCALE.

Logan. That can be found in the Huronian area flanking the Green Mountain range in Vermont, and possibly in the forest country about Connecticut Lake. The Swift Water series is more nearly related to the Helderberg.

1. *Porphyritic gneiss* or granite.—This occurs at the corners of the towns of Littleton, Whitefield, Bethlehem and Dalton, forming an oval-shaped isolated area of about four square miles in extent. The Ammonoosuc River flows along its eastern border, and there is a large hill in the western or central part, about 600 feet above the river. This area is the most northern exposure of the porphyritic gneiss in the State. It is supposed to be connected with the great Lafayette-Moosilauk range beneath the overlying Bethlehem group, and to be the oldest formation in New Hampshire. If compared with ancient systems of gneissic rocks elsewhere, it would agree best with certain portions of the Laurentian in New York and Canada.

2. *Bethlehem gneiss.*—As signified by the name, this formation is best developed in Bethlehem. It lies in a nearly east and west direction, disturbing the continuity of the newer systems, which usually trend northeasterly in its neighborhood. The disturbances may be seen in tracing the Coös and Helderberg groups from Lisbon into Littleton. The prevailing rock is very granitic in aspect, and often carries a hydro-mica in place of the common mica of gneiss. The feldspar is usually of a reddish cast. Two or three other areas of the same age occur in the valley of Connecticut River, in Haverhill, Lyme, Orford, Hanover and Lebanon.

3. *Gneiss.*—This designation applies to a rock somewhat allied to No. 2, bounded by No. 1 on the north, and separated from the Coös group by No. 2. The valley of Littleton village seems to have been excavated mainly out of this area, and the absence of ledges in the lower ground makes it difficult to understand its precise limits. The rock bordering No. 2 may belong to this group, it being a mica schist slightly feldspathic, and abundant in the more southern areas of the Bethlehem formation. Mann's and Oak Hills in Littleton are the best exposures of this gneiss. It seems also to be distinct from the "White Mountain series" of my reports.

4. *Lisbon Group.*—The best part of Littleton, much of Munroe, and portions of Lisbon and Lyman are underlaid by a series of greenish rocks consisting of conglomerate, hydro-mica and cupriferous schists, quartzites and dolomites, estimated at 4295 feet in thickness. A section roughly measured across the members, in the south part of Lisbon (see fig. 10), gave the following order and thickness: first, hydro-micaceous conglomerates, 756 feet; second, hydro-mica schists with cupriferous layers, 3539 feet. The upper division often carries a nodular mass of

nearly white quartz, from 50 to 150 feet thick. This estimate came from measurements on the county map for the hypothenuse, and the average dips afforded data for the two acute angles of the triangle. The results underestimate rather than exaggerate. Another member, seeming to lie at the summit of the Lisbon group, but not occurring on this section, resembles diabase. This is found sparingly in the very southeast corner of Lyman, adjoining the southern gneissic area in North Lisbon, and more abundantly directly in contact with the Helderberg group in Littleton. Indeed Professor Dana thinks it may be a member of the fossiliferous series.* In Lancaster this member has its maximum development, and I have formerly mistaken it for gneiss, because of the great amount of feldspar present. The range of it at North Lisbon will prove specially interesting. This group probably crops out in the south part of Littleton. Before my last observations, I had supposed the connection between the chlorite rock of Littleton and the Lisbon development was well established, but the great abundance of gravel, sand and loam renders it difficult to discover any connection at the surface. But no doubt can prevent the belief of the direct continuation of the Lisbon group into Bath, Wells River village and Newbury, Vermont, and so on down the Connecticut to Charlestown.

The western range is more extensive. It abounds in copper schists along Gardner's Mountain, between Lyman and Monroe; but it is not necessary to describe the western range in this communication.

5. *Lyman Group.*—The prevailing rock of this series is a drab, soapy quartzite, weathering nearly white. Parts of it are conglomeratic, the pebbles being essentially the same with the rock itself. The pebbles have generally been flattened and elongated by pressure. Professor C. A. Seely's analysis of this rock shows silica 82·98, peroxide of iron 6·35, alumina 5·99, magnesia 0·36, alkalies 15·62 = 101·30. The other division of this group is a conglomerate of pure quartz pebbles, rarely distorted by pressure, with a micaceous cement, some pyrrhotite, and gold to the amount of eighty cents to two dollars to the ton of rock. This member is not usually above one hundred feet in thickness, but is very conspicuous because it resists decomposition. I have spent much time in tracing out its curves, breaks and throws, so as to illustrate the forces that have operated to derange the New Hampshire formations.

Along the Lisbon section, the whitish quartzite has a thickness of only 200 feet, because of a down-throw. When the whole thickness is present, it must amount to 2,330 feet, and that after allowing for a possible fold.

* This Jour., III, vol. vi, p. 350.

6. *Clay slate.*—This is the auriferous slate of Lyman and Bath. A study of its structure over the area of a map shows it to be normally synclinal, and resting upon the Lyman group chiefly. This structure is best recognized in Bath. On passing northerly, the basin is broken up into fragments by the rising up of the uneven floor, the segments indicating irregularly the synclinal. But, after reaching the neighborhood of the Dodge gold mine, the strata are monoclinal, and continue thus till they disappear beneath the Helderberg. The case is analogous to those in Berkshire County, Mass., described recently by Professor Dana.* Analysis of this slate in Lyman gave Professor Seely silica Silica 72·98, peroxide of iron 6·35, alumina, 5·99, magnesia ·36, potash 5·61, soda 9·92 = 101·21. Thus this slate resembles the common schist of the Lyman series. Possibly it was derived from the decomposition of the latter.

The synclinal form of these slates confirms the general theory of structure in this neighborhood, already presented. For, if this area is a basin, it must lie upon older strata; and, if both sides of the slate are flanked by a similar succession of strata, the latter must be relatively older. In fact, this slate is flanked first by the Lyman schist, and that in turn by the Lisbon group. On the southeast, the latter joins on to the Coös series, and on the west it comes in contact with the same slate, in both cases newer rocks; but ultimately gneiss is found after one or more inferior undulations. The slate range on the west is supposed to extend to Bernardston, Mass., on West Mountain. On one section it has a thickness of 1500 feet, with a maximum of 1800. It carries auriferous veins of quartz, which have yielded from $18 to $25 of gold to the ton of rock, when milled. These slates resemble the auriferous rocks of Nova Scotia, which Mr. A. R. C. Selwyn, geologist to the Dominion of Canada, ranks with the Lingula flags of Great Britain.

7. *Coös Group.*—This consists of quartzites, mica schist, both with and without staurolite, argillaceous schist, clay slates with garnets and obscure mica, possibly phyllite, calcareous mica schist, hornblende rocks and various sandstones. My third New Hampshire report gives four sections across this group, in Lisbon, Orford, Lyme and Hanover, with an average thickness of about 10,000 feet. Subsequent investigations modify all our published statements respecting this group. The limestone and gneiss of the sections must be eliminated; the proof of this is very evident. The gneiss in Hanover underlies the same succession of quartzite, staurolite, mica schist and hornblende rock in two or three localities along the same section line, and thus all the rocks are repetitions instead of one unbroken series. In Haverhill, the gneiss with limestone under-

* This Journal, III, vol. v, p. 90.

lies the supposed Coös quartzite, with a strike differing from that of the latter as much as thirty or forty degrees. I do not find any regular gneiss in the Coös group anywhere in the State. It is a curious fact also that there are extensive ranges of what seems to be the Coös quartzite resting unconformably upon the gneiss, without any connection with mica or hornblende schist. They must continue to be ranked as Cöos till we have evidence to the contrary. The Coös group may also embrace the "calciferous mica schist" of Vermont. The original definition of this group expressly excluded the latter rock. Further study will be required to make this position a sure one.

Errors have arisen in consequence of confounding the Coös group with the White Mountain series. Dr. T. Sterry Hunt has included these two series in one, which is stated to be pre-Cambrian, with the name of *Montalban*. Originally he grouped them under the provisional name of *Terranovan*, and presented considerations leading to the belief that they might lie near the horizon of the Potsdam. As already shown elsewhere, it is better to separate the Coös and White Mountain series, though both abound in the related silicates, staurolite and andalusite. The latter may be pre-Cambrian, but the former cannot well be older than Cambrian; and Professor Dana thinks the Bernardston region proves all the Coös rocks to be of Helderberg age.

In consequence of Dr. Hunt's error just cited, Prof. Dana has also misapprehended the relations of these two systems, supposing that Dr. Hunt had used the term "White Mountain series" in the same sense in which I had previously employed it, in my 1869 report. He says:* "A large part of the rocks that have been distinguished as of the "Montalban" or White Mountain series in New Hampshire, and regarded of pre-Silurian age, are here included, and are hence nothing but altered Helderberg sediments." He then quotes from Dr. Hunt's Indianapolis address the names of the rocks belonging to this series, which include both the Coös and White Mountain series. If it be granted that the former of these groups belongs to the Helderberg, it remains to be proved that the latter is even as modern as the Cambrian. The White Mountain series does not certainly enter the area represented upon the map, and hence any notice of it here requires an apology. It is mentioned only because it has been erroneously associated with the Coös group. The two series are unlike in mineral character, thickness and geographical distribution.

8. *Swift Water Series.*—This will be defined in the next issue of the Journal.

* This Journal, III, vol. vi, p. 348.

9. *Helderberg strata.*—These form the proper subject of this communication. In brief, they are sandstones, quartzites, conglomerates, hornblende rocks, argillaceous schists, clay and calcareous slates, crinoidal and coralline limestones, siliceous limestones, and perhaps other varieties. They occupy three areas, which may be termed the Littleton, North Lisbon and Lyman terranes.

The fossils consist of *Favosites basaltica*, *Zaphrentis*, *Pentamerus Knightii*, large and small crinoidal-stem fragments, a gasteropod and fucoids. The third is the most important, since it determines the precise horizon of the limestone. Samples of all the varieties having been sent to Mr. E. Billings, he has written that the brachiopod is closely allied to the *Pentamerus Knightii* of the Lower Helderberg, while the other fossils do not as yet afford anything so definite in regard to geological equivalency.

"The fossils came last night. They are *Favosites Gothlandica*, a large crinoidal column, a *Pentamerus* closely allied to if not identical with *P. Knightii*, and a gasteropod. The two first prove nothing. The *Pentamerus* goes far to show that the rock is about the top of the Upper Silurian—say Lower Helderberg. The gasteropod is just like some that occur in the same horizon. I do not consider the fossils sufficient to decide the age of the rock very closely, but only that it is either Upper Silurian or Lower Devonian. I have specimens of the Bernardston encrinites and will endeavor to determine whether they are identical with yours or not."

Two points of importance suggest themselves in this connection. 1. The horizon at Littleton is different from the Helderberg at Owl's Head, Province of Quebec, which by the included *Atrypa reticularis* has been shown to be the Upper Helderberg. It is hence most likely that we have both the Helderberg limestones in New England, as well as the strata enclosed by them in New York. 2. If there is a limit, the facts indicate that the Bernardston limestone is Lower Helderberg. That locality furnishes only large crinoidal stem fragments, which have heretofore been compared with the upper limestone in New York. But the Littleton and North Lisbon localities furnish crinoidal fragments having the same dimensions in company, at the first place named, with a characteristic fossil of the lower division. The Bernardston and Littleton localities occupy the same valley, and are nearer to each other than the former is to New York. Hence from present indications the Massachusetts limestone may be regarded as Silurian instead of Devonian.

[To be continued.]

ART. XLIV.—*Rabies Mephitica;* by REV. HORACE C. HOVEY, M.A.

MY subject concerns alike medical science and natural history. For while proving the existence of a new disease, some singular facts will be brought to light about a familiar member of the American fauna. It is cruel to add aught to the odium already attached to the common skunk (*Mephitis mephitica* Shaw; *M. chinga* Tiedmann). But, clearly, he is as dangerous as he is disagreeable. In a wild state he is by no means the weak, timid, harmless creature commonly described by naturalists; although it is said that, if disarmed of his weapons of offence while young, he may be safely domesticated.

A peculiar poison is sometimes contained in the saliva of animals belonging to the canine and feline families, the production of which, it has been generally supposed, is limited to them. Other animals, of the same or of different species, may be inoculated with this virus; the result being a mysterious malady, which men have observed from the days of Homer and Aristotle, but which has never been either cured or understood. This frightful disease has been called, from its origin, *Rabies canina*, and from one of its symptoms, *hydrophobia*. Probably it is not communicable by any species but those with which it originates. A few instances have been recorded to the contrary; but they were so imperfectly observed as merely to stimulate us to further investigation. It is stated by the best medical writers (e. g., Watson Gross, and Aitken), as an undeniable fact, that no instance is known of hydrophobia having been communicated from one human being to another, although many patients, in their spasms, have bitten their attendants. An interesting case, but inconclusive, being the only one of its kind, is reported by M. Guillery, in which an aged man experienced spontaneous hydrophobia. (Bulletin of Belgian Academy, No. 8, 1871.) In such exceptional instances there may have been previous inoculation, unnoticed or forgotten; for the least particle of this deadly poison will be efficient, and yet it is always tardy in its period of incubation.

The facts now collated will show, it is thought, one of two things, either that the hydrophobic virus is both generated and communicated by some of the *Mustelidæ* as well as the *Felidæ* and *Canidæ;* or else, that a new disease has been discovered, which generically resembles *Rabies canina*, while differing from it specifically. My judgment favors the latter opinion, decidedly, for reasons to be adduced; and accordingly I may name this new malady, from the animal in whose saliva it is generated,

Rabies mephitica.

The varieties of *Mephitis* are notorious for the singular battery with which they are provided by nature. It consists of two anal glands from which, by the contraction of sub-caudal muscles, an offensive fluid can be discharged in thread-like streams, with such accuracy of aim as to strike any object within fifteen feet. This secretion is either colorless, or of a pale yellow hue. It is phosphorescent. Viewed from a safe distance, its discharge looks like a puff of steam or white smoke. Its odor is far more persistent than that of musk. If too freely inhaled it causes intense nausea, followed by distressing gastric cramp. In minute doses it is said to be a valuable anti-spasmodic. If so, why not experiment with it as a cure for hydrophobic convulsions? It is not known what the effect would be of injecting this fluid beneath the skin. Interesting results might be attained by any one who was willing, in behalf of science, to investigate further in this inviting path! There certainly seems to be some connection between it and the disease under consideration; for, in every instance, the rabid skunk has either exhausted his mephitic battery, or else has lost the projectile force by which it is discharged. Perhaps the secretion is only checked by the feverish state of the system. Possibly there may be a causative connection between this inactivity of the anal glands and the generation of malignant virus in the glands of the mouth.

An adventure, while on a summer tour amid the Rocky Mountains, first called my attention to the novel class of facts about to be presented. Our camp was invaded by a nocturnal prowler, which proved to be a large coal-black skunk. Anxious to secure his fine silky fur uninjured, I attempted to kill him with small shot, and failed. He made characteristic retaliation; and then, rushing at me with ferocity, he seized the muzzle of my gun between his teeth! Of course the penalty was instant death. An experienced hunter then startled us by saying that the bite of this animal is invariably fatal, and that when in perfect apparent health it is always rabid. He resented our incredulity and confirmed his statement by several instances of dogs and men dying in convulsions shortly after being thus bitten.

On mentioning this adventure to H. R. Payne, M.D., who had been camping with miners near Cañon City, Col., he said that at night skunks would come into their tent, making a peculiar crying noise, and threatening to attack them. His companions, from Texas and elsewhere, had accounts to give of fatal results following the bite of this animal.

Since returning to Kansas City, I have had extensive correspondence with hunters, taxidermists, surgeons and others, by which means the particulars have been obtained of forty-one cases of *Rabies mephitica*, occurring in Virginia, Michigan, Illinois, Kansas, Missouri, Colorado and Texas. All were fatal except one; that was the case of a farmer, named Fletcher, living near Gainsville, Texas, who was twice bitten by *M. macroura*, yet recovered and is living still. On further inquiry it was found that he was aware of his danger, and used prompt preventive treatment. Another case was alleged to be an exception; that of a dog which was severely bitten in a long fight with a skunk, but whose wounds healed readily and without subsequent disease. It seems, however, that this dog afterward died with mysterious symptoms like those of hydrophobia in some of its less aggravated forms.

Instead of burdening this article with a mass of circumstantial details, a few cases only will be given best fitted to show the peculiarities of the malady; and those are preferred that are located on the almost uninhabited plains of western Kansas, because there the mephitic weasels would be least liable to be inoculated with canine virus.

A veteran hunter, Nathaniel Douglas, was hunting buffalo, in June, 1872, fourteen miles north of Park's Fort. While asleep he was bitten on the thumb by a skunk. Fourteen days afterward singular sensations caused him to seek medical advice. But it was too late, and after convulsions lasting for ten hours he died. This case is reported by an eye-witness, Mr. E. S. Love, of Wyandotte, Kansas, who also gives several similar accounts.

One of the men employed by H. P. Wilson, Esq., of Hayes City, Kansas, was bitten by a skunk at night, while herding cattle on the plains. About ten days afterward he was seized with delirium and fearful convulsions, which followed each other until death brought relief. Mr. Wilson also reports other cases, one of which is very recent. In the summer of 1873, a Swedish girl was bitten by a skunk while going to a neighbor's house. As the wound was slight and readily cured, the affair was hardly thought worthy of remembrance. But on Jan. 24th, 1874, the virus, which had been latent for five months, asserted its power. She was seized with terrible paroxysms. Large doses of morphine were administered, which ended both her agony and her life.

In October, 1871, a hunter on Walnut Creek, Kansas, was awakened by having his left ear bitten by some animal. Seizing it with his hand, he found it to be a skunk, which after a struggle he killed, but not until his hand was painfully punctured and lacerated. He presented himself for treatment to Dr. J. H. Janeway, army surgeon at Fort Hayes, from whom I have the facts. The wounds in the hands were cauterized, much to the man's disgust, who thought simple dressing* sufficient. He refused to have the wound in the ear touched, and went to Fort Harker to consult Dr. R. C. Brewer. Twelve days afterward the latter reported that his patient had died with hydrophobic symptoms.

Another hunter, in the fall of 1872, applied to Dr. Janeway to be treated for a bite through one of the alæ of the nose. He had been attacked by a skunk, while in camp on the Smoky River, two nights previous. He had been imbibing stimulants freely and was highly excited and nervous. A stick of nitrate of silver was passed through the wound several times. He was kept under treatment for two days, when he left to have a "madstone" applied. He afterward went home to his ranch, and died in convulsions twenty-one days from the time he was inoculated.

I give but one more of the cases reported to me by Dr. Janeway. In October, 1871, he was called to see a young man living in a "dug-out," a few miles from the fort. He had been bitten by a skunk, seventeen days previous, in the little finger of the left hand. His face was flushed, and he complained that his throat seemed to be turning into bone. On hearing the sound of water poured from a pail into a tin cup, he went into convulsions, that followed each other with rapidity and violence for sixteen hours, terminating in death. This man's dog had also been bitten, and it was suggested that he had better be shut up. He chanced at the time to be in the hog-pen, and he was confined in that enclosure. Ere long he began to gnaw furiously at the rails and posts of the pen and to bite the hogs; until the bystanders, convinced that he was mad, ended the scene by shooting all the animals in the pen.

It is evidently the opinion of Dr. Janeway that the malady produced by mephitic virus is simply hydrophobia. Should he be correct, then all that is established by these facts would be this, viz: that henceforth the varieties of *Mephitis* must be classed with those animals that spontaneously generate poison in the glands of the mouth and communicate it by salivary inoculation. From this, as a starting-point, we might go further and seek a solution of the whole mystery of hydrophobia in the theory that this dread malady primarily originates with the allied genera of *Mephitis*, *Putorius* and *Mustela*, widely scattered over the earth;* being from them transferred to the

* Since forwarding this article for publication, I have obtained an answer to my inquiries made in California through my friend, Dr. J. G. Tidball, respecting the *Mephitis zorilla*. He described it as a very pretty little animal which usually allows itself to be killed without resistance. But he adds that its bite is highly dangerous, causing a fatal disease like hydrophobia.

I regret that he gives no particulars of actual cases. But his testimony is interesting, as it brings into condemnation a species of *Mephitis* quite different from *M. chinga*.

Felidae and Canidae and other families of animals. And then, if it could be proved experimentally that the characteristic mephitic secretions contained an antidote for the virus of the saliva, we should have the whole subject arranged very beautifully!

I am favored by Dr. M. M. Shearer, surgeon in the 6th U. S. Cavalry, with notes from his case-book, of four cases in which persons have died from the bite of the skunk; and he also mentions additional instances reported to him by other observers. He thinks there is a marked difference between the symptoms of their malady and those of hydrophobia. I shall refer to his testimony again, but pause for a moment to notice his final conclusions, from which, original and interesting as they are, I must dissent. He says: "I regard this virus as being as peculiar to the skunk as the venom of the rattlesnake is to that creature; and not an occasional outbreak of disease as the *aestus veneris* of the wolf or the *rabies canina.*" Singular as this theory may seem, it is not wholly without support. It is remarkable that of all the cases thus far reported to me there is but *one instance of recovery.* It is stated in Watson's Physic (vol. i, p. 615) that of one hundred and fourteen bitten by rabid wolves only sixty-seven died; and of those bitten by rabid dogs the proportion is still less. But mephitic inoculation is sure death. Then again it is to be observed that the only peculiarity noticeable in these biting skunks is the arrest of their effluvium. They approach stealthily, while their victims are asleep, and inflict the deadly wound on some minor member—the thumb, the little finger, the lobe of the ear, one of the alæ of the nose. How different from the fierce assault of a mad dog! How subtle and snake like! It may be remarked, also, that dogs are generally as cautious and adroit in attacking these odious enemies as they are in seizing venomous snakes. But we must remember, on the other hand, that thousands of skunks are killed annually, partly as pests and partly for the fur trade; and it is incredible that an animal whose ordinary bite is as venomous as that of a rattlesnake, should so seldom resort to that mode of defence, if it be his.

The resulting disease resembles hydrophobia more than it does the effects of ophidian venom. But here, as observed at the outset, the likeness is only generic, while specifically there are marked differences. These have purposely been kept in the back-ground until now. And in giving a differential diagnosis, I shall avoid repetitious details, and combine facts gathered from many sources with the close and accurate observations which Dr. Shearer has put at my disposal.

1. The period of incubation is alike in *Rabies canina* and *Rabies mephitica.* That is, it is indefinite, ranging from ten

days to twelve months, with no opportunity meanwhile for subsequent inoculation. But during the incubative period of *R. mephitica*, no perceptible changes take place in the constitution as in hydrophobia. In only one instance was there unusual nervousness, and that might have been due to alcohol. In every case, where there was time for it, the wounds healed over smoothly and permanently, and in several instances not even a scar was visible. In no case was there recrudescence of the wound, always seen in hydrophobia. Indeed, there were so few premonitions of any kind that, in most instances, the attending physicians themselves supposed the ailment to be simple and trivial, until the sudden and fearful convulsions came on to baffle all their skill.

2. Characteristic pustules form, in hydrophobia, beneath the tongue and near the orifices of the sub-maxillary glands. (See Aitken, Sci. and Pract. Med., vol. i, p. 653.) These were not reported in a single case of *R. mephitica*. Dr. Shearer looked for them carefully in all his cases, but did not find them.

3. The specific action of hydrophobic virus affects the *eighth pair of cranial nerves* and their branches, especially the œsophageal branch, the result being great difficulty in swallowing; and the motor nerve of the larnyx, causing sighing, catching of the breath, and difficulty in expelling the frothy mucus accumulated in the throat. These invariable accompaniments of *R. canina* are usually wanting in *R. mephitica;* the exceptions being in the case of the Swedish girl, who complained of pain in her chest; and the young man, Dr. Janeway's patient, whose constriction of the throat was decided, as well as his sensitiveness to water. Dr. Shearer's patients had no such trouble. A taxidermist, who has seen four dogs die from *R. mephitica*, in Michigan, says they did not seem to have any fear of water, or other signs which he had supposed were characteristic of *R. canina*. Ordinary hydrophobia, again, is marked by constant hyperæsthesia of the skin, so that the slightest breath of air will precipitate convulsions. But, in *R. mephitica*, fanning the face affords relief, and even cloths dipped in water and laid on the forehead were soothing!

4. In hydrophobia the perceptions are intensified, so that even the deaf are said to have their hearing restored; the pupils are strongly dilated, imparting to the eyes a wild, glaring expression; the spasms are tonic, i. e., steady and continuous; the pulse is feeble; and delirium is occasionally relieved by lucid intervals. But the symptoms are wholly different in *R. mephitica:* there is oscillation of the pupil; the spasms are clonic, i. e., marked by rapid alternate contraction and relaxation of the muscles; small but wiry radial pulse and rapid carotids; positive loss of perception and volition throughout,

until delirium ends in persistent unconsciousness, simultaneously with cold perspiration and relaxation of the sphincters.

5. The mode of death is by asthenia in both forms of rabies; but in *R. canina* the frightful struggles of nature to eliminate the poison are more prolonged than in *R. mephitica;* and in the latter they may, on occasion, be still further abridged by the use of morphine, which has no narcotic effect upon the former, even in the largest doses and injected into the veins!

I have thus endeavored to describe, and also to explain, these strange and painful phenomena. I must leave the reader to form his own decision, only hoping that some one may be induced to follow this pioneer work in a new path, by further and more able investigations of his own.

Kansas City, Mo., Feb. 24th, 1874.

ART. XLV.—*On the nature of the action of Light upon Silver Bromide;* by M. CAREY LEA, Philadelphia.

WHEN silver bromide is exposed for a moment to light, it undergoes no visible change, but has acquired the property of passing to an intense black when treated with pyrogallic acid and an alkali.

As to the nature of this black substance, there has existed considerable diversity of opinion. In a paper published on the subject about a year since by Captain Abney, F.C.S., he expressed the opinion that it was an oxide of silver.

Some years since, while investigating the action of light upon silver iodide, I succeeded in proving that the black substance, which is produced when silver iodide is exposed to light in presence of silver nitrate, contains iodine, and is, therefore, either a sub-iodide or an oxy-iodide. The quantity obtained was too small to enable me to ascertain which. When this black substance was treated with nitric acid, normal yellow silver iodide was left behind, and silver was found on solution.

I have recently applied the same treatment to the bromine compound with similar results. I find that when silver bromide is treated with pyrogallic acid and alkali after exposure to light, the black substance which remains contains bromine, and is resolved by nitric acid into normal silver bromide (left behind as a pale yellow film) and silver, which passes into solution. It is therefore either a sub-bromide or an oxybromide, not an oxide, probably the former.

The existence of these compounds is evidently an argument for doubling the atomic weight of silver, as has recently been proposed on other grounds.

ART. XLVI.—*Notes on some of the Fossils figured in the recently-issued Fifth volume of the Illinois State Geological Report;* by F. B. MEEK.

[Continued from page 376.]

Agassizocrinus Troost; plate XXI.—In looking at the species of this group figured on the plate cited above, it would seem scarcely possible that such forms as that represented by figs. 12*a*, *b*, *c*, with a small, distinctly divided base, showing a well-defined scar for the attachment of a column, ought to be ranged in the same genus with such species as *A. dactyliformis* and *A. conicus* (represented by figs. 7 and 8 of the same plate), showing no traces of a scar of attachment, and having the base large, and nearly or entirely without divisions. As important, however, as such distinctions would naturally be supposed, specimens have been found that seem to show that no well-grounded generic distinctions can be founded on these differences. On the contrary, it is highly probable that in all cases the young of these species were attached by a column, and had the base divided into five parts; but that, as they advanced in size, some became free at much earlier stages of growth than others, thus causing the base to enlarge more rapidly than the other parts, and to assume the character of a single solid piece, with the scar of attachment entirely obsolete. Some species, such as those represented by figs. 10 and 12, may have even remained attached by a slender column during their whole life.

Dr. Rœmer proposed to found a genus *Astylocrinus* for the species with an undivided base and without a column; the specimen represented by our figure 7*a* being his typical form, the original of which belongs to Dr. Shumard's collection.

Fusulina gracilis and *F. ventricosa;* figs. 7 and 8, plate XXIV.—These names were temporarily written on the explanations of this plate, merely with the view of keeping in mind forms with which it was thought desirable that they should be compared in revising the text for the press, and not with any intention of ultimately using them as if the fossils were known really to belong to two distinct species. They are, on the contrary, almost certainly extreme varieties of the common *F. cylindrica* Fischer. The first does not agree *exactly*, in form, with the California specimens for which the name *F. gracilis* was originally proposed, though it does not differ very materially. The other is smaller, and even more ventricose than the Kansas specimens named *ventricosa*, as a mere variety of *F. cylindrica*, and is better entitled to rank as a distinct variety than that figured on the same plate under the name *F. gracilis.*

Zeacrinus (*Hydreionocrinus?*) *acanthophorus* M. and W.; plate XXIV, figs 11*a*, *b*.—The specimen of this species, shown by fig. 11*a*, illustrates the ventral extension so greatly developed in this and the allied groups. In this species it is narrowed below and dilated and truncated at the top, around which it is armed by a row of spines that extend out horizontally. I have long been familiar with these spines, as seen detached (see figs. 11*d*, *e*) and scattered among the other fossils of our Coal-measures; but, until the discovery of a specimen of this species with some of them in place, connected with the ventral extension, their true position with relation to the other parts of the crinoid has remained a mystery. They have often been confounded with the spines of *Z. mucrospinus* of McChesney (see figs. 12*a*, *b*, same plate) from which, however, it will be seen that they differ materially in the form of the larger or attached end, those of *Z. mucrospinus* being really modified and greatly produced second-radial pieces of the body; while those under consideration are similarly produced vault or ventral pieces, having no direct connection with the radial series whatever.

Since seeing the specimen illustrated by our figs. 11*a*, *b*, I have, as elsewhere suggested, very strongly suspected that the type on which Dr. de Koninck founded his genus *Hydreionocrinus* may really differ in no essential generic or subgeneric characters from *Zeacrinus* (Troost) Hall, 1858. It is true, Dr. de Koninck supposed that his type was entirely destitute of free arms: or, in other words, that arms were united ("soldered") laterally along their entire length, so as to form a large, cylindrical, upward extension as wide as the body, with its upper end truncated and tightly covered over by solid vault-pieces, the outer row of which project out horizontally, as radiating, spine-like processes, around the top, precisely as the spines are seen radiating from the top of the ventral prolongation (see fig. 11*b*) of our type. The great difficulty, however, of understanding how the *arms* of a crinoid could perform their natural functions, thus immovably united so as to form such a cylindrical prolongation, closely sealed over above by solid vault-pieces, certainly favors the conclusion that the part supposed by Dr. de Koninck to be thus formed, may really be the central extension of a flattened specimen from which the arms had been accidentally removed.

The species illustrated by our figures 11*a*, *b*, has the ventral part narrowed downward; but there are several others known in this country in which it is as wide all the way down, or very nearly as wide, as the body below; and, if a specimen of one of these had had its arms accidentally broken away, and its body and ventral part more or less flattened by pressure, it would certainly present *very* nearly, if not exactly, the appearance of

Dr. de Koninck's type, as illustrated by him. That is, the removal of the arms and the pressing inward of the body and radial pieces might give the walls of the ventral part the appearance of rising directly from the top of the radial series.

If this suggestion in regard to the upper parts of the type of *Hydreionocrinus* should prove true, as I am very strongly inclined to believe it will, that name having priority of date over *Zeacrinus*, would have to take precedence, as there appear to be no generic or subgeneric differences in the structure of the body of the typical forms of these proposed groups. In this case, all of the American species, and a few foreign forms, described under the name *Zeacrinus*, would have to be ranged under *Hydreionocrinus*.*

Archæocidaris? (sp. undt.); pl. XXIV, figs. 13*a–e*.—These spines almost certainly belong to a species described by Dr. Shumard, in the Trans. St. Louis Academy Sci., vol. i, p. 223, under the name *A. aculeatus*. As Dr. Shumard never figured his species, however, and we have had no opportunity to compare our Illinois specimens with his types, it is barely possible that they may belong to a distinct species.

Septopora Cestriensis Prout, pl. XXIV, figs. 14*a*, *b*, *c*; and *Synocladia virgulacea var. biserialis* Swallow, figs. 15*a*, *b*, *c*, of same plate.—The occurrence of these two names as quoted above, in the explanations of plate XXIV, without any reference to them in the text, might lead to the conclusion that we were intending to recognize the specimens figured as representing two separate and distinct genera. On the contrary, however, as would have been fully explained if the text of the volume could have been prepared as originally intended, the figures were drawn mainly to show the *exact generic*, and possible *specific*, identity of the fossils on which these names were founded.

Dr. Prout's typical species of his proposed genus *Septopora*, represented by our figures 14*a*, *b*, *c*, cited above, was from the Chester limestone of the Lower Carboniferous; while Prof. Swallow's species, represented by figs. 15*a*, *b*, *c*, came from the Upper Coal-measures. That they are *generically* identical, however, no one will for a moment question; and few will doubt that they really belong to the same *species*, as even the slight differences seen in the mode of branching, as illustrated by our figures 14*a* and 15*a*, are not constant; and the apparent difference represented in the dimorphous pores, as seen in figs. 14*b* and 15*b*, are due rather to differences in the state of

* I have elsewhere mentioned these apparent close relations between *Hydreionocrinus* and *Zeacrinus*, and only call attention to it again here because I can do so in connection with figures that seem to illustrate these relations more clearly than can be done by words.

preservation of the specimens than to any natural distinction.*

In the Proceedings of the Philad. Acad. Nat. Sci. for 1870, we published some remarks on this subject, showing that Dr. Prout's proposed genus *Septopora* agrees in all essential generic characters with Prof. King's older genus *Synocladia*; and that Prof. Swallow's *Synocladia virgulacea var. biserialis* is entirely distinct *specifically* from the European *S. virgulacea* Phillips (sp.), but almost certainly identical specifically with the type of Dr. Prout's proposed genus *Septopora*. In the Paleontology of Eastern Nebraska, plate VII, published in Dr. Hayden's Nebraska Report of 1872, I have also fully illustrated the well defined specific differences between the so-called variety *biserialis*, and the foreign *S. virgulacea*.

It is all the more important that the true relations of the American form *biserialis* to the proposed genus *Septopora*, as well as to the real *Synocladia virgulacea* of Europe, should not be lost sight of, because its occurrence here in certain Coal-measure rocks of the West has been appealed to as an evidence that these beds should be referred to the Permian epoch. The genus *Synocladia*, and especially the species *S. virgulacea* of Phillips, has long been regarded as especially characteristic of the Permian; consequently, if the American form can be properly referred to that species, its abundant occurrence here in the rocks referred to might very naturally be supposed to have some bearing on the question in regard to their Carboniferous or Permian age. The fact, however, that we now know this form (*biserialis*) to range, not only through our whole Coal-measures, but to be represented by a type beyond all question *congeneric*, and almost certainly *specifically* identical, even in the upper members of our Lower Carboniferous limestones, shows how exceedingly cautious we should be in deciding such questions on the evidence of a few species, even before their geological range has been well determined among our own rocks.†

This, however, is only one of a number of examples that might be mentioned, of *peculiar* types that have until recently been known only from our Coal-measures, which are now known to have their closely allied representatives among the

* It may be well to explain here that Dr. Prout's figures of his type, published in the Trans. St. L. Acad. Sci., are far from being as accurate as those he published of other species of Polyzoa; though his description is quite clear and satisfactory. Our figs. 14*a*, *b*, *c* were drawn from one of his typical specimens.

† It should be stated just here, that Dr. Etheridge of London has recently described a species of *Synocladia*, similar to the *biserialis*, from the Lower Carboniferous limestone of Midlothian. (See Ann. and Mag. Nat. Hist., vol. xii, fourth series, p. 189, pl. 8, 1873.) He also adds some remarks on the relations of *Synocladia* King and *Septopora* Prout, *exactly* sustaining our views on this point, contained in the paper above alluded to, published in the Proceedings of the Philad. Acad. Nat. Sci. in 1870.

fossils of the upper member of the Lower Carboniferous limestones of the same region. For instance, the curious species *Zeacrinus acanthophorus* and *Z. macrospinus* (pl. XXIV, figs. 11*d*, *e*, and 12*a*, *b*), of the Coal-measures, are represented by *Z. formosus* and *Z. armiger* (pl. XXI, figs. 2*c*, *d*, and fig. 3*a*) of the Chester limestone; while the singular solid-based forms of *Agassizocrinus*, figured on pl. XXI, from the Chester, are represented by a similar form from the Coal-measures, as shown by our figure 4 of plate XXIV.

Aviculopecten neglectus Geinitz; pl. XXVI, figs. 7*a*, *b*, *c*, *d*.—This little shell was originally described by Prof. Geinitz, under the name *Pecten neglectus*, in his work on the fossils from the Coal-measures of Nebraska, its hinge characters being unknown to him. In a review of that work, and in the Paleontology of Eastern Nebraska, I placed it provisionally in the genus *Aviculopecten*, from general external characters, its hinge being then equally unknown to me; though no doubts were entertained in regard to its being clearly distinct from the more modern genus *Pecten*. While studying the Illinois Coal-measure fossils, some years later, at Springfield, Illinois, I discovered that it has a very peculiar hinge-plate or area, entirely different from that of *Aviculopecten;* or, in other words, that it is provided with a comparatively large, oblique, central cartilage-pit, and a row of smaller ones crossing the area at right angles, all along, both before and behind the larger, oblique, central pit, as shown in our figure 7*c*, cited above. Although intending, on account of this character, ultimately to make a very different disposition of this shell in the text, the name *Aviculopecten neglectus* was temporarily written opposite its number on the explanations of the plate, merely to keep in mind, for the time being, its identity with the Nebraska shell. The text of the volume, however, for the reasons already explained, was not revised and written out as at first intended, and consequently the name *Aviculopecten neglectus* was printed in the explanations of the plate so originally written, and the references in the text given accordingly.

From the hinge characters of this shell, as illustrated by our figures, it will be at once seen to differ widely from *Aviculopecten*, and, at least in this peculiarity, to be much more nearly like *Pernopecten* of Winchell. After a careful comparison, however, with that genus, I am led to the conclusion that our shell cannot be properly referred to it, for the following reasons. In the first place, the decided obliquity of its large central cartilage-pit, together with the coexistence of a series of smaller *true cartilage-pits* along the hinge, like those of *Inoceramus*, and the nature of its auricles, but more especially the apparent prismatic structure of the shell, are all characters pointing to close relations with the *Aviculidæ.* On the contrary, the want of even the slightest obliquity of either the central cartilage-pit, or of the shell itself, in *Pernopecten*, as well as the shortness and equality of its auricles, without the faintest traces of a byssal sinus, together with its general physiognomy, all indicate affinities to the modern genus *Amusium*, and consequently a position in the *Pectinidæ.* It is true, the presence of a row of minute cartilage-pits along the entire hinge, *if they realty exist in Pernopecten*, would be an anomalous feature in the *Pectinidæ;* but I very strongly suspect that what appear to be such in Prof. Winchell's type are really only interlocking crenulations of the hinge-line, and not true cartilage-pits. At least, this seemed to me to be the case, on examining Prof. Winchell's type-specimens. However this may be, I am, as already stated, decidedly of the opinion that these shells cannot be properly referred to the same genus;* and, knowing of no other group to which our type could be with more propriety referred, I have proposed for it the name *Euchondria*,† which will render it necessary to write the name of the type species *Euchondria neglecta.*

Aviculopecten carboniferus Stevens (sp.); pl. XXVI, fig. 8 (not figs. 8*a*, *b*). It will be seen that there are, by mistake, two very different shells designated on this plate by the number 8. That is, one simply numbered 8, and one numbered 8*a*, *b*. The first, which is not mentioned in the text, or on the explanations of the plate, is the form Dr. Stevens described, many years back, in this Journal, under the name *Pecten carboniferus;* while more recently Prof. Swallow named it *Pecten Broadheadii*, and Prof. Geinitz, in his work on the Nebraska fossils, has called it *Pecten Hawni.* I have elsewhere, long back, called attention to the identity of these proposed species, and referred the shell provisionally to the genus *Aviculopecten*, as it is *certainly* not a true *Pecten.* Good figures of both valves of this shell may be seen in my Report on the Paleontology of Eastern Nebraska, published in Hayden's Nebraska Report of 1872.

The other form, numbered 8*a*, *b*, on the same plate, is *Nucula parva* of McChesney.

Nuculana (sp. undt.); pl. XXVI, fig. 10.—This is the same as at least one of the forms referred by Prof. Geinitz, in his work on the Nebraska fossils, to *Nucula Kazunensiz* de Verneuil. It

* In order that the reader may correctly understand how unlike the shell under consideration is to *Pernopecten*, and how closely the latter resembles *Amusium*, it is only necessary to compare the figure of our shell with figs. 12*a*, *b*, *c* of the same plate, and figs. 11*a–g* of pl. IX, Palæont. Eastern Nebraska in Hayden's Nebraska Report of 1872, representing *Entolium aviculatum* Swallow (sp.), which is *exactly* like the type of *Pernopecten*, excepting in not having a crenate hinge.

† See page 445 of this volume.

looks like de Verneuil's figures; but, when we remember that his species came from the Permian rocks of Russia, and that his typical specimens consist merely of imperfect impressions in a mass of rock, it must be admitted that we have very unsatisfactory means of comparison, and that the probabilities are much against the conclusion that this American Coal-measure shell is really the same as the Russian species.

It is also very similar to *Nuculana bellistriata* (=*Leda bellistriata* Stevens), originally described from our western Coal-measures, and very common at that horizon in Illinois, to which species I referred it as a variety (*N. bellistriata, var. attenuata*), in Hayden's Nebraska Geological Report of 1872, page 206. It seems, however, both in Illinois and Nebraska, to be always decidedly smaller, and more attenuated at the posterior extremity, than the form generally referred to Dr. Stevens' shell, and I am now inclined to regard it as a distinct, more delicate species. Its smaller size is also quite as strong an objection to the supposition that it may be identical with de Verneuil's species.

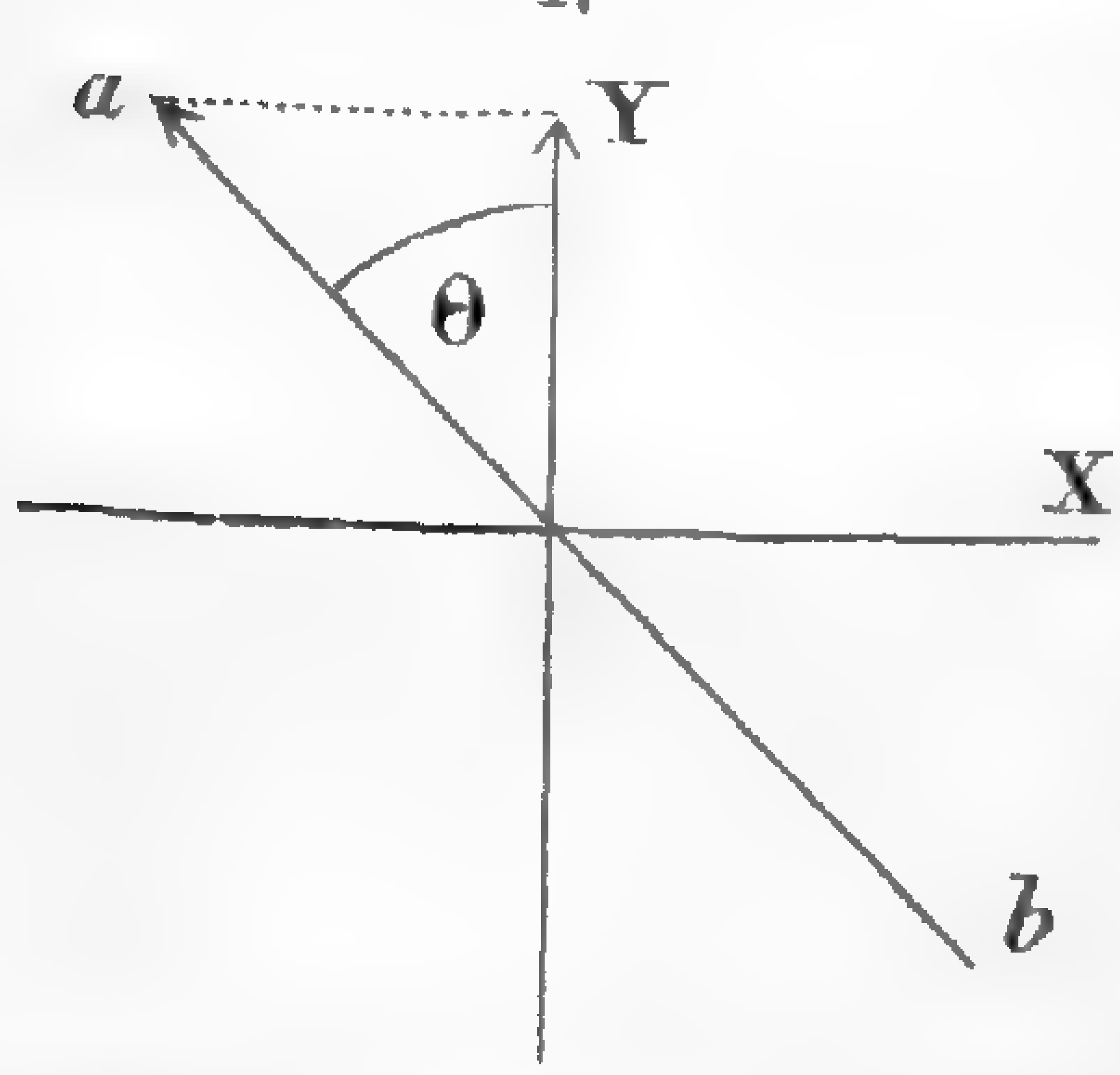
[To be continued.]

ART. XLVII.—*Brief Contributions from the Physical Laboratory of Harvard College.* No. V.—*On a method of freeing a Magnetic Bar from the influence of the Earth's Magnetism;* by JOHN TROWBRIDGE.

IN the Proceedings of the Philosophical Society, Manchester, March 19, 1867, Dr. J. P. Joule gives the following method of freeing magnets from the inductive action of the earth's magnetism: "Two magnets are prepared whose magnetic moments are as nearly equal as possible. In the deflexion experiments these magnets are used separately, or they may be placed simultaneously on opposite sides of the suspended magnet to produce a greater deflexion. In these experiments the inductive force of terrestrial magnetism is transverse to the axis. Let one of the magnets be suspended, and let the other be placed parallel to it with its center exactly below that of the suspended magnet, and with its axis in the same direction. The force which the fixed magnet exerts on the suspended one is in the opposite direction from that of terrestrial magnetism. If the fixed magnet be gradually brought nearer to the suspended one, the time of vibration will increase, till at a certain point the equilibrium will cease to be stable, and beyond this point the suspended magnet will make oscillations in the reverse position. By experimenting in this way a position of the fixed magnet is found at which it exactly neutralizes the effect of terrestrial magnetism on the suspended one. The two magnets are fastened together so as to be parallel, with their axes turned the same way, and at the distance just found by experiment. They are then suspended in the usual way and made to vibrate together through small arcs. The lower magnet exactly neutralizes the effect of terrestrial magnetism on the upper one, and since the magnets are of equal moment, the upper one neutralizes the inductive action of the earth on the lower one." (Electricity and Magnetism, Clerk Maxwell, vol. ii, p. 105.)

It is desirable in many investigations on magnetism to free a needle not only from the inductive action of the earth, but also from its directive influence. The method that I have adopted is the following: An ordinary tangent galvanometer is so constructed that the coil is free to turn about a vertical axis, and also about a horizontal one. The coil is first placed in a plane perpendicular to the magnetic meridian; it is then turned about its horizontal axis until the component of the strength of the current acting in the horizontal plane shall be just equal and opposite to the horizontal component of the earth's magnetism. In fig. 1, if we denote by θ the angle which the plane of the coil makes with a vertical plane, and by $a\ b$ the strength S of the current passing through the coil of the galvanometer; we shall have $S \cos\theta = \mu$, in which μ is the counter-balanced force of the earth's magnetism. Under these conditions the magnetic needle is evidently in a state of unstable equilibrium, and, if placed perpendicularly to the magnetic meridian, will vibrate through small arcs free from the influence of the earth, and subject only to the attraction in the field of force in which it may be placed.

1.



A bar of soft iron placed in the vertical plane which passes through the suspension of the needle perpendicular to the magnetic meridian, at a suitable distance from one of the poles of the needle, serves to bring it back to zero, just as the controling magnet serves a similar purpose in Thomson's reflecting galvanometer. This method constitutes practically a new astatic system.

It is often desirable to test the changes which take place in a closed circuit in which the full force of a current acts. Such as the effect of heating the electrodes (Faraday's Experimental Researches in Electricity, vol. i, s. 1637), the effects of induction, and similar qualitative experiments In the use of a reflecting galvanometer in such experiments there are great difficulties; one of the most obvious of which is the large divergence of the spot of light from the zero of the scale, and the deflection of the magnet into a state of minimum sensibility. Table I. will show the effect of the introduction of resistances in the closed circuit when the needle is placed by this method in a plane perpendicular to the magnetic meridian, and a controling magnet serves to bring it back to its original position when the resistances are removed.

TABLE I.

Resistances in ohms.	Degrees of divergence.	Difference.
·16	7	
·32	14	7
·48	22	8
·54	30	8

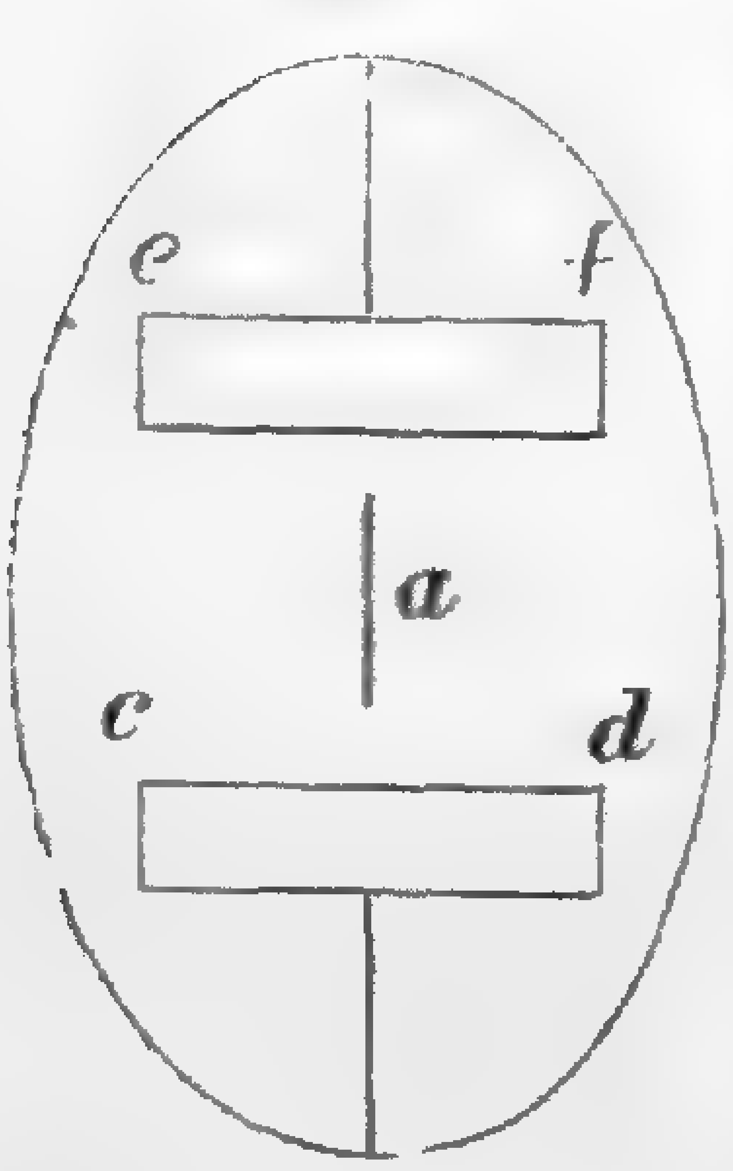
In the following Table II, the same resistances were introduced into a closed circuit, the strength of which was measured by the same instrument used as a tangent galvanometer:

TABLE II.

Resistances in ohms.	Degrees of divergence.	Difference.
----	68·5	
·16	66·5	2
·32	64	2.5
·48	62	2
·54	60	2

It will be seen that, estimated in this way, the new method is much the more sensitive. It possesses the advantage also that the needle can remain at zero even while a strong current is passing through the galvanometer; and is in a position, at the same time, to be influenced by the slightest change in the electrical condition of the closed circuit.

2.



The method supplies a magnetic horizontal pendulum for the investigation of the inductive effects of large magnetic masses. It also serves to determine the force of attraction of a galvanic coil on a magnet placed in its axis. In the following figure the ellipse represents the projection of the plane of the coil of the galvanometer on the horizontal plane, when it makes an angle θ with the vertical plane. a represents the magnetic needle standing at right angles to the magnetic meridian; and $c\,d$ and $e\,f$ galvanic coils placed parallel to the magnetic meridian.

For small vibrations of the needle, the law $MT=\frac{\pi^2 k}{t^2(1+\theta)}$ evidently applies; in which

M is the magnetic moment,

T the force of attraction at a given distance x from the centers of the coils,

$t=$ the time of vibration,

$\theta=$ the coefficient of torsion of the suspension thread,

k the moment of inertia of the needle.

For the vibrations of the same needle under the influence of the earth we have—$MT_1=\frac{\pi^2 k}{t_1^{\,2}(1+\theta)}$; eliminating M, π^2, k, and $(1+\theta)$ we have $\frac{T}{T_1}=\frac{t_1^{\,2}}{t^2}$, or $T=\frac{t_1^{\,2}}{t^2}T_1$, in which T_1 is the force of the horizontal component of the earth's magnetism in absolute units. We can thus, by this method, express the force of attraction of a galvanic coil at a given point on its axis where the lines of force are sensibly parallel in absolute units.

No. VI.—*A Note on Melde's Experiment;* by W. Lowery.

In performing Melde's experiments upon the vibrations of strings, it is desirable to change the tension of the vibrating cord in a continuous manner. The ordinary method of attaching weights to the cord does not admit of this with precision; and with small weights the movement of the weight itself, on account of the rapid vibration of the string, prevents the formation of the ventral segments with regularity. I have adopted the following method: A glass tube graduated into millimeters is weighted so as to float in a vertical position. This is attached to the silk cord which hangs from the prong of the tuning fork, and is placed in a glass vessel filled with water. This latter vessel is provided with a siphon, by means of which the water can be drawn off at pleasure. It will be readily seen that, by drawing off the water from the larger vessel, the displacement produced by the graduated glass tube is diminished, and the tension of the string thereby is increased. By diminishing or increasing the amount of water in the larger vessel the tension can be diminished or increased to the desired extent.

In order to make quantitative experiments, the tube is, in the first place, connected with the arm of a delicate hydrostatic balance. The balance is adjusted when the level of the water in which the tube floats is at the zero of the millimeter scale. In order to avoid errors in reading, it is best to use a cathetometer. The weights, which are necessary to keep the index of the balance at zero, when the level of the water in the outer vessel falls through the millimeter divisions on the graduated tube, are noted. The upward pressure of the water, and consequently the tension upon the suspending cord, are then given in grams.

In order to show the regularity of the method, the following results of one experiment are given. In the experiment, a glass tube which, immersed at 110 mm. on the scale, weighed two grams, gave, when the level of the water in the outer vessel was lowered, the following:

Immersed at	110	mm.	Weight =	2	grams.
"	102	"	"	2·5	"
"	93·5	"	"	3·0	"
"	85·	"	"	3·5	"
"	76·5	"	"	4·0	"
"	67·5	"	"	4·5	"
"	60·	"	"	5·0	"
"	43·0	"	"	5·5	"

In these experiments a fall of 8·1 mm. corresponded to a difference of ·5 of a gram. It is evident by increasing the size of the outer vessel that a large amount of water would measure a slight displacement. When the cord was set in vibration, the following results were obtained:

Point of immersion.	Weights in grams.	Vibrations.
110	2·	6
84	3·5	5
76	4·	4
30	6·7	3

The ratio of the numbers in the second and third columns will be found to follow Melde's law.

For qualitative or quantitative experiments upon beats or Lisajous curves this method of loading the prong of a tuning fork can advantageously replace the bit of wax or the sliding weight, since we have at our command a quick and precise method of adjustment.

No. VII.—*A Spark Adjuster for the Holtz Machine;* by James J. Minot.

In the Annalen der Physik und Chemie, Bd. 137, s. 452, and Bd. 139, s. 509, under the title of "Schwache Elektrische Funke in Luft., von P. Riess," a method is described of obtaining different kinds of electric sparks from the Holtz machine.

The following method seems to be preferable to that described in the above mentioned articles: Having insulated the outer coating of the two Leyden jars, which form a part of the ordinary Holtz machine, short thick wires were connected with these outside coatings and terminated in two brass pointers or conductors, so arranged that the distance between them could be varied at pleasure. With this arrangement the following results were noted. At first the conductors were placed in connection with each other; it was then found that a series of sparks were given off between the conductors of the machine. The extreme length of spark obtainable with the machine which was used was 20 cm. The sparks so obtained were large and luminous, passing only at intervals, and requiring a certain electric tension before they would leap across the space. Then the pointers connected with the outer coatings of the Leyden jars were drawn apart about 13 mm.; it was then found that a succession of fine thread-like sparks passed across the space separating the conductors of the machine, whereas there was no such appearance between the pointers connected with the jars. But at intervals a larger spark, not so bright as the normal spark of the machine, would jump across the conductors, and simultaneously with this a similar spark passed between the pointers. This fine line of sparks was found to have a peculiar form, being brightest and largest at the ends of the conductors of the machine, fading away to a lighter and redder tint, and being of a thread-like character in the space between the knobs of the conductors.

It was found, if the distance between the conductors of the machine exceeded a little that between the pointers connected with the Leyden jars, that no large sparks passed between either set of conductors, but only a series of thread-like discharges. When the distance between the conductors of the machine was less than that between the pointers, a similar result was obtained. When the pointers were but a few millimeters apart a continuous loop-like discharge passed between them, which was not interrupted by the occasional passage of a bright spark, and was not coincident in path with the latter. By varying the distance of the pointers of the Leyden jars the number and character of the sparks could be changed at will. This method possesses the advantage that by an easy adjustment of these pointers the form of the electric spark can be readily studied. In experimenting upon the passage of the spark through different media we can, by this method, diminish the diameter, so to speak, of the spark, and can change quickly from the spark discharge to that of the brush. The change in tone of the sound of the discharge when the distance between the pointers is varied is quite marked.

No. VIII.—*Effect of Condensers on the Brush Discharge from the Holtz Machine;* by J. W. Fewkes.

The readiest way of producing the brush discharge is to connect the negative conductor of the Holtz machine with the ground, and to place the hand in its neighborhood with one finger extended toward the positive conductor; the brush then makes its appearance on the positive conductor. Faraday, in his Experimental Researches in Electricity, vol. i, p. 454, et seq., has fully described this peculiar electric discharge. Since his epoch the use of condensers in connection with electrical machines has so altered their range, that the following experiments were instituted to observe the effect of such condensers on the brush discharge.

Experiment 1. If both condensers were removed from the machine and the negative pole connected with the ground, the brush made its appearance on the knob of the positive conductor.

Exp. 2. A plate of vulcanite, held in the hand, was interposed between the conductors and produced the same effect as the hand alone. If, however, the vulcanite were supported on an insulated stand, no brush appeared. A metallic disk held in the hand failed to produce the brush.

Exp. 3. A condenser was connected with the positive pole; the other connection remaining as before. The brush made its appearance, but was less stable, and consisted of a uniform straight spark, of 25 mm., terminating in interweaving rays. There was a continual tendency to break into the ordinary electric spark; due, doubtless, to the increase of electric density resulting from the use of the condenser.

Exp. 4. For the condenser of the machine a larger one from five to six times its capacity was substituted. The brush disappeared.

Exp. 5. A pointed metallic wire was held in the hand and directed toward the brush. It immediately disappeared.

The conclusions to be drawn from the above experiments appear to be as follows: The use of condensers of large surfaces is prejudicial to the continuance of the brush discharge. This peculiar phenomenon, which results, evidently, from the tendency of the electric state on the positive conductor to combine with the state which it induces on a neighboring large and poor conductor, is best produced by a continuous supply of a positive charge, small comparatively in quality, which is as continuously dissipated by the inductive action of the large body in the neighborhood. Condensers of a smaller extent of surface than those in common use on the Holtz machine appear better adapted to produce a continuous brush discharge.

With large condensers the brush changes into a glow on the knob of the positive conductor. It will be instructive to quote the remarks of Faraday (Experimental Researches in Electricity, vol. i, § 1526) on this glow discharge. "*Diminution of the charging surface* will produce it; thus when a rod 0·3 of an inch in diameter, with a rounded termination, was rendered positive in free air, it gave fine brushes from the extremity; but occasionally these disappeared, and a quiet phosphorescent, continuous glow took their place, covering the whole end of the wire, and extending a very small distance from the metal into the air. § 1528. *Increase of power in the machine* tends to produce the glow; for rounded terminations, which will give only brushes when the machine is in weak action, will readily give the glow when it is in good order."

It is evident that diminution of the charging surface in these experiments of Faraday resulted in a greater electric density at the termination of the conductor used, which was also the effect with an increase in power of the machine. In our experiments the effect of condensers is analagous to those produced by Faraday in diminishing the charging surface, and increasing the power of the machine. For, although the condenser really increases the charging surface, still the electric density is increased in a greater ratio. The spectrum of the brush discharge consists of a number of fine lines in the blue and violet end of the spectrum, which are difficult to measure on account of the faint light. The spectrum differs greatly from that of the spark enhanced by the use of condensers. The spectrum of the latter is a continuous one crossed by bright lines. I have measured the wave-lengths of the most prominent ones, and find their value as follows:

Wave-length of observed lines.	Atmospheric lines.
5767	5767 N. Plücker
5687	5686 N. "
5620	
6019	
5185	5184 Thalen
5003.5	5003 N. Huggins

The lines due to nitrogen are thus seen to be the most prominent. There were many fine lines, especially in the violet, which were partially obscured by the light of the continuous spectrum; and therefore did not admit of exact measurement. These lines were apparently those which appeared in the spectrum of the brush discharge. The bright lines whose wave-lengths we have given above were wanting in the brush discharge. The solid particles of the brass conductors do not appear to contribute to the formation of the light of the spark, for no prominent zinc or copper lines were observed in the spectrum. The spark was produced also between brass knobs covered with sheet platinum, but no difference in the spectra was observed.

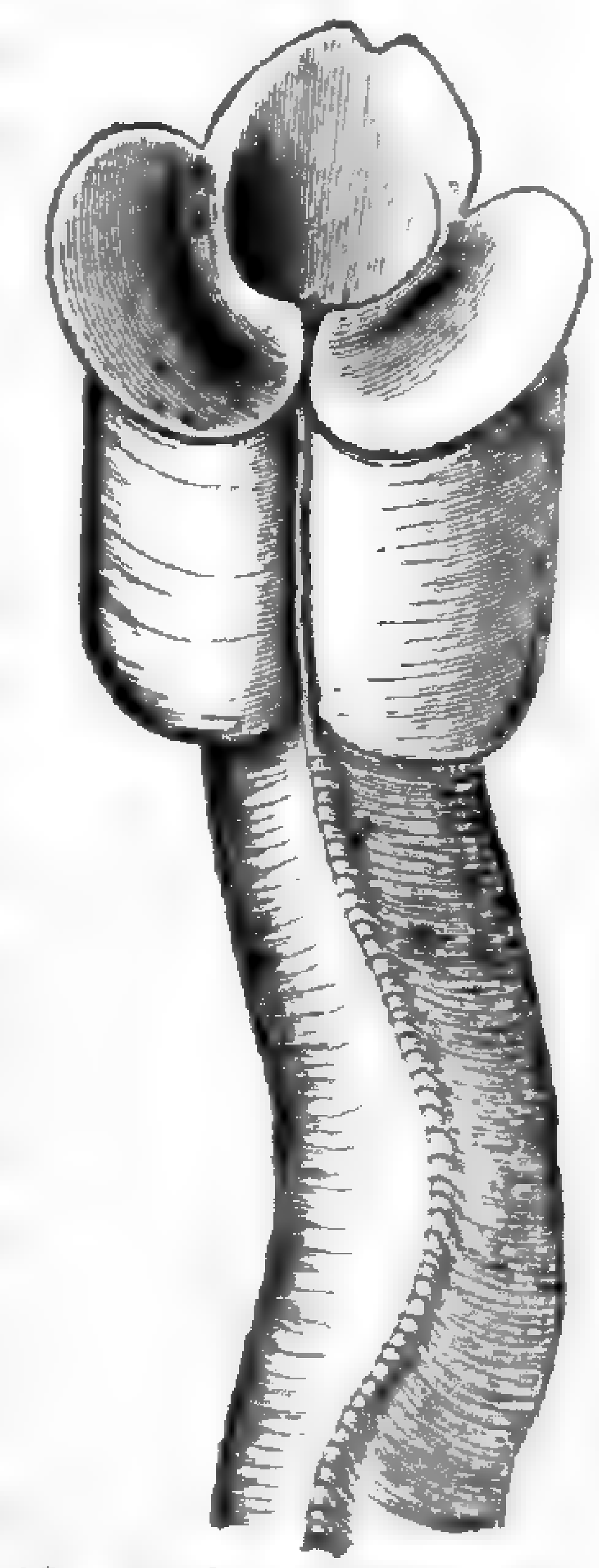
ART. XLVIII.—*Brief Contributions to Zoölogy from the Museum of Yale College.* No. XXIX. *Results of recent Dredging Expeditions on the Coast of New England.* No. 7; by A. E. VERRILL.

[Continued from page 414.]

THE extensive bank near Cashe's Ledge, consisting for the most part of hard bottoms, proved to be one of the most interesting of the localities on our coast that has been investigated by means of the dredge. The crest of Cashe's Ledge, situated about ninety miles south from the mouth of the Penobscot River, rises to within four fathoms of the surface. Since it is in range with the extensive belt of syenitic rocks which, running in a southwestern direction, terminate in the mountains of Mt. Desert and the smaller islands situated farther south, Cashe's Ledge is, in all probability, a sunken island belonging to the Mt. Desert group. The rocks on Mt. Desert are mostly massive reddish colored syenites, often passing into granite and hyperite. Many of the fragments brought up by the dredge, at Cashe's Ledge, are of the same kind of rock, and the mud in the same region is reddish brown, and under the microscope shows grains of reddish feldspar, garnet and other minerals characteristic of this granitic formation. The dredgings in this region commenced a few miles south of the crest of the ledge, in fifty-two fathoms, and extended several miles farther southward, to the depth of ninety fathoms. Several hauls were made, both with tangles and dredges, but the whole collection was combined together (under No. 21, in the table of temperatures, p. 408). The single temperature observation taken at the bottom in this place gives 43° F., but this is probably somewhat too high. Although the bottom was generally rocky, stony, or gravelly, some patches of mud were evidently encountered, for several species of Annelids, very characteristic of muddy bottoms, were obtained in abundance. Among these were *Terebellides Stroëmi*, *Melinna cristata*, *Nothria opalina* V. (plate IV, fig. 1), *Ninoë nigripes* V. (plate IV, fig. 3), *Lætmonice filicornis*, and several other species.

Among the numerous interesting Crustacea from Cashe's Ledge were *Lithodes maia;* several species of *Hippolyte; Caridion Gordoni*, a rare shrimp, previously dredged in the Bay of Fundy and at Saint George's Bank; *Œdiceros lynceus; Tritropis aculeata; Paramphithoë pulchella*, and other interesting Amphipods; *Scalpellum Stroëmi*, a rare barnacle, dredged afterward off Cape Cod, in one hundred and forty-two fathoms, and in 1872, in four hundred and thirty fathoms, off Saint George's Bank, but much more abundant on Cashe's Ledge than in the other localities. The Annelids were also numerous: among them was a large oblong scaly worm, allied to *Aphrodita*, but with larger and less concealed, smooth scales, fewer and stiffer setæ, and long slender antennæ; it is probably *Lætmonice filicornis* Kinberg, though it does not fully agree with the description. The same species was dredged in 1870, in ninety fathoms, in the Bay of Fundy. The *Leodice vivida* (*Eunice vivida* Stimp)., *Nothria conchylega*, *Trophonia aspera*, *Thelepus cincinnatus*, *Potamilla oculifera*, *Sabella zonalis*, and an undetermined species of *Sabella*, which constructs tubes covered with sand, were abundant. The beautiful *Protula media* Stimpson was also quite common, its tubes adhering to shells and stones in company with several species of *Spirorbis*, and the curious *Vermilia serrula* (figure 3, and plate VI, fig. 1); the latter is remarkable among the *Serpulidæ* for the two curious chambers which are formed at the sides of the opening of the tube, when mature (figure 3), but these are entirely wanting in immature specimens. A species of *Phascolosoma*, having a thick opaque integument, covered with minute papillæ, but without hooks, and usually coated with dark brown or blackish dirt, was quite abundant; it is probably the *P. boreale* Keferstein, described from Greenland specimens.

3.



Among the most interesting Mollusca were several fine specimens of *Anachis Haliæeti* (Jeff. sp.), new to American waters; *Astyris rosacea; Ptychatractus ligatus*, a rare shell; *Turritella erosa*, unusually common; *Calliostoma occidentale;* a large species of *Polycera*, with long dorsal papillæ; *Hanleia mendicaria;* fine specimens of *Pecten Islandicus;* a few small ones of *P. tenuicostatus*, one of which is white on both sides and peculiar in other respects; and single living specimens of *Arca pectunculoides* and *Torellia vestita*, which were also dredged in 1872, near Saint George's Bank. *Ascidia mollis* V. (figure 2, p. 409) and several other Ascidians were abundant; as was also *Terebratulina septentrionalis*. The Bryozoa were unusually numerous and fine: among the more interesting of these were *Discofascigera lucernaria; Tubulipora crates* Stimp., *Hornera lichenoides; Farrella familiaris; Flustra solida* Stimp., abundant; *Discopora Skenei; Myriozoum coarctatum*, etc.

The Echinoderms were very numerous and of great interest. The "tangles" did very good service in securing large numbers of fine starfishes, some of which were previously quite rare, and others entirely unknown on our coast. Among the most interesting of the Echinoderms were several specimens of *Schizaster fragilis; Hippasteria phrygiana*, a magnificent starfish, rarely met with on our coast, of which about a dozen good specimens, of all sizes, were obtained by means of the tangles; *Archaster Parelii*, a fine Norwegian starfish not previously known from American waters; several specimens of *Archaster arcticus*, previously known on the American coast from a single specimen dredged near St. George's Bank, in 1872, in 150 fathoms. *Leptasterias tenera*, *L. compta*, and *Stephanasterias albula* were common; *Pteraster militaris* occurred sparingly, and a small undetermined starfish allied to *Asterina* was represented by a single specimen. The Ophiurans were also abundant, but mostly of the common species; those of most interest were *Ophiacantha spinulosa* and a small *Amphipholis*, with six arms, found adhering to a sponge. Two specimens of a fine Comatula, apparently identical with *Antedon Sarsii*, previously known only from the northern coasts of Europe, were also caught by the tangles. Hydroids were abundant, but mostly identical with species found in the shallower waters of Casco Bay and Bay of Fundy. Among the Actinians were *Urticina nodosa* and *Bolocera Tuediæ*, both of which were added to the American fauna last year by our dredgings near Saint George's Bank and in the Bay of Fundy, and were also obtained this year off Casco Bay. *Cornulariella modesta* V. (plate VIII, figs. 1, 2) occurred on Jeffrey's Ledge. Sponges were very abundant on Cashe's Ledge, and of many species: among them were *Thecophora ibla* Thompson (plate VIII, fig. 8), also dredged last year by the Saint George's Bank expedition; *Tethya hispida* Bowerbank; two or three species of *Polymastia*, one of which has the surface densely hispid with long spicules, except around the bases of the large and rather long mammilliform prominences; several specimens of *Hyalonema longissimum;* and a cup-shaped thin, flexible sponge having spicula with six acute rays (much like those of *Euplectella*, "attenuated rectangulated hexradiate" and quadrifurcate hexradiate stellate.) But the most interesting sponge was a large species, of which several fine specimens were obtained. This in general appearance and form somewhat resembles a *Tethya*, and in the character of the spicula it agrees with *Dorvillia* Kent. This sponge consists of a broad, convex, often nearly hemispherical, upper portion, two to four inches in diameter, supported on a broad stout, but short, peduncle, usually two or three inches broad in large specimens, and somewhat less in height, the peduncle usually forming about one-half of the total height, which may be three or four inches. The peduncle is composed of very long, slender, irregularly aggregated, mostly setiform spicula, more or less appressed to the surface, but with the upper ends mostly free; together with a few small dependent fascicles. The "head" or upper portion of the sponge mass is firm and rather dense, composed chiefly of radiating bundles of large and long slender spicula, often more than half an inch long, many of which, at the external layer, divide into three horizontal or recurved branches or prongs, each of which usually forks near the end into two acute divergent branches, serving to support the cortical layer, which is more or less irregular and uneven, but firm; some of the spicula referred to project beyond the surface, and nearly the whole exterior is rudely and densely hispid, with long, setiform, acute spicules, which project unequally from the surface, the free ends of many of them being half an inch or more in length. Among the projecting spicula, and supported by them, are small, elongated oval, or fusiform, masses of soft sarcode, which are probably to be regarded as external gemmæ. Scattered irregularly over the upper surface, and especially around the periphery, are large, often very elongated, rounded, or angular, sunken areas or pits, often half an inch across, surrounded by a more or less prominent margin supported by stiff projecting spicula. The bottom of these pits is formed by a thin membrane or diaphragm, perforated by very numerous small round or oval openings, which are quite variable in size, even in the same area, and in many cases are so numerous and large in the central part as to be separated only by a mere network, when they become polygonal. This perforated membrane is filled with minute, many-rayed double-stellate spicula, with a small number of much larger ones having four or five acute rays. Beneath the diaphragm the pits become more or less funnel-shaped, and communicate with large round anastomosing channels, which ramify through the sponge-mass.

It seems necessary to refer this remarkable form to the genus *Dorvillia*, and therefore I propose to consider it a new species under the name of *Dorvillia echinata*.*

The greater part of "Jeffrey's Ledge," situated from 6 to 15 miles northeast from Cape Ann, has a hard, gravelly and stony bottom, in 24 to 33 fathoms of water. Most of the species found there are the same as those previously enumerated from the hard bottoms in Casco Bay, though a few additional ones were found. The hard bottoms on Stellwagen's Bank, north of Cape Cod, in 22 to 44 fathoms, have a fauna very similar to that of Jeffrey's Ledge, but with some species not met with in the other localities. *Astrophyton Agassizii* was taken here, in great abundance, with the tangles, though it did not occur either on Jeffrey's Ledge, Cashe's Ledge, nor in Casco Bay. *Asterias vulgaris* was also very abundant and of large size.

Among the Mollusca from Stellwagen's Bank were *Aporrhais*

* It may be the *Thenea muricata* Gray (Bowerb. sp.), but does not agree with the description. The sponge referred to by Whiteaves (this volume, p. 211) was probably an imperfect specimen of the same species. Our species was attached to pebbles, etc.

occidentalis; numerous specimens of *Mactra polynema* (*ovalis* Gould) and *Cyprina Islandica*, and a few dead valves of *Glycimeris siliqua* and *Panopœa Norvegica.* The latter occurred also on Jeffrey's Ledge.

List of species from the hard bottoms on the outer banks.

In the following list the species dredged on Cashe's Ledge (loc. 21) are designated by c following the name; those from Jeffrey's Ledge by j; those from Stellwagen's Bank by s. Those species dredged on these bottoms, but belonging more properly to muddy bottoms, are designated by an asterisk (*) prefixed; some of these doubtless came from scattered patches of muddy bottom, but others may have burrowed beneath the stones and dead shells.

ARTICULATA.

Pycnogonida.

Pycnogonum pelagicum.	c. j.
Nymphon grossipes.	c. j.

Crustacea.

Hyas araneus.	s.
H. coarctatus.	c. j. s.
Cancer irroratus.	s.
Lithodes maia.	c.
Eupagurus pubescens.	j. s.
E. Kroyeri.	j. s.
E. Bernhardus.	s.
Hippolyte spina.	j. s.
H. borealis.	c. j. s.
H. pusiola.	c. s.
H. polaris.	j.
H. aculeata.	j. s.
H. Fabricii.	j. s.
Pandalus annulicornis.	c. j. s.
Caridion Gordoni.	c.
Crangon vulgaris.	s.
Mysis, sp.	j. s.
Thysanopoda, large sp.	c. s.
Cumaceæ, sp.	c.
Acanthozone cuspidata.	j. s.
Paramphithoë pulchella.	c. s.
P. (?) cataphracta.	c. s.
Tritropis aculeata.	c. j. s.
Moëra Danæ.	c. s.
*Œdiceros lynceus.	c.
Melita dentata.	c.
Phoxus Kroyeri.	s.
Podocerus, sp.	c.
Leucothoë grandimanus St.	c.
Metopa, sp.	c.
Unciola irrorata.	c. s.
Ptilocheirus pinguis.	s.
*Ampelisca, with red spots.	s.
Caprella, spiny sp.	c. s.
Asellodes alta.	c.
Praniza cerina.	c.
Anthura brachiata.	j.
Bopyrus, on Hippolyte.	j.
Balanus porcatus.	c. j. s.
Scalpellum Stroëmi.	c.

Annelida.

*Lætmonice filicornis.	c.
Eunoa Œrstedii.	j. s.
E. nodosa.	j.
Harmothoë imbricata.	c.
Antinoë Sarsii.	c.
Euphrosyne borealis.	c.
Cryptonota citrina St.	j.
*Nephthys ingens St.	c.
Nereis pelagica.	c. j. s.
Phyllodoce Grœnlandica.	c.
Leodice vivida.	c. j.
Nothria conchylega.	c.
*N. opalina V.	c. s.
*Ninoë nigripes V.	c.
*Lumbriconereis fragilis.	c. s.
Rhynchobolus albus (?)	c. s.
*Goniada maculata.	s.
Trophonia aspera St.	c. j.
Tecturella flaccida St.	c.
Brada sublævis St.	c.
Nicomache lumbricalis.	c. s.
Cistenides granulatus.	c. j. s.
*Samytha sexcirrata.	c.
*Melinna cristata.	c.
*Terebellides Stroëmi.	c.
Thelepus cincinnatus.	c. j. s.

Annelida—continued.

Amphitrite cirrata.	C.
A. intermedia.	C.
Myxicola Steenstrupii.	C.
Sabella zonalis St.	C. J.
Sabella, sp., in sandy tubes.	C. J. S.
Potamilla oculifera.	C. J. S.
Chone, sp.	C.
Protula media St.	C. J.
Filigrana implexa.	C.
Vermilia serrula St.	C. J.
Spirorbis lucidus.	C. J. S.
S. quadrangularis St.	C. J. S.
S. nautiloides (?).	C. J.
Ichthyobdella, sp.	S.

Gephyrea.

Phascolosoma boreale (?).	C.
P. cæmentarium.	C. J. S.

Turbellaria.

Nemertes affinis (?). C.

Mollusca.

Gastropoda.

Admete viridula.	C. S.
Bela turricula.	S.
B. decussata.	C. J. S.
B. harpularia.	S.
Anachis Haliæeti.	C.
Astyris rosacea.	C. J.
Buccinum undatum.	C. J. S.
Neptunea curta.	C. J. S.
N. decemcostata.	C. S.
Neptunella pygmæa.	C. J. S.
Tritia trivittata.	S.
Ptychatractus ligatus.	C. S.
*Aporrhais occidentalis.	J. S.
Natica clausa.	C. J. S.
Lunatia Grœnlandica.	C. J. S.
L. immaculata.	S.
L. heros, var. triseriata.	S.
Amauropsis helicoides.	
Torellia vestita.	C.
Velutina zonata.	C. S.
V. lævigata.	C. J. S.
Lamellaria perspicua.	C.
Turritella erosa.	C. S.
T. acicula.	J.
Odostomia, sp.	S.
*Scalaria Grœnlandica.	S.
Acirsa borealis.	S.
Margarita obscura.	J. S.
M. cinerea.	C. J. S.
M. Grœnlandica.	C. J. S.
Calliostoma occidentale.	C. J.
Diadora noachina.	C. S.
Lepeta cæca.	C. J. S.
Polycera, sp.	C.
*Cylichna alba.	J. S.
*Philine lineolata.	C.
*Scaphander puncto-striatus.	C. S.
Hanleia mendicaria.	C. J.
Trachydermon albus.	J. S.
*Entalis striolata.	C. J.
*E. agilis (?).	C.

Lamellibranchiata.

Zirphæa crispata.	J. S.
Glycimeris siliqua.	S.
Saxicava arctica.	C. J. S.
Panopæa Norvegica.	J. S.
*Macoma sabulosa.	C. S.
*Cyprina Islandica.	S.
Cardium pinnulatum.	C. J. S.
*Cyclocardia borealis.	C. S.
*C. Novangliæ.	C. J. S.
*Astarte lens.	C. J.
*A. undata.	C. J. S.
A. quadrans.	J. S.
Arca pectunculoides.	C.
Mya truncata.	C. J.
Lyonsia hyalina.	S.
Clidiophora trilineata.	S.
Mactra polynema.	S.
*Leda tenuisulcata.	C. J. S.
*Nucula delphinodonta.	J.
*Yoldia obesa.	C.
Modiola modiolus.	C. J. S.
Modiolaria discors.	C. J. S.
M. corrugata.	C. S.
M. nigra.	J.
*Crenella glandula.	C. J.
Pecten Islandicus.	C. J. S.
P. tenuicostatus.	C. S.
P. Grœnlandicus (?)	C.
Anomia aculeata.	C. J. S.

Tunicata.

Ascidia mollis V.	C. J. S.	Amarœcium glabrum.	C. J. S.
Ascidiopsis complanatus.	C. J. S.	A. pallidum.	C. J. S.
Cione tenella.	C.	Leptoclinum albidum.	C. J. S.
Cynthia carnea.	C.	L. luteolum.	C. J. S.
Molgula retortiformis.	J. S.	Lissoclinum, sp.	

Brachiopoda.

Terebratulina septentrionalis.	C. J. S.

Bryozoa.

Idmonæa pruinosa St.	C. J. S.	Bugula Murrayana.	C. J. S.
Tubulipora crates St.	C.	Gemellaria loricata.	J. S.
Tubulipora, sp.	C.	Flustra solida.	C. J. S.
Hornera lichenoides.	C.	Membranipora, sp.	J. S.
Crisia eburnea.	C. J.	Discopora Skenei.	C.
Farrella familiaris.	C.	Lepralia, several sp.	C. J. S.
Alcyonidium, sp.	C. J.	Myriozoum coarctatum.	C.
Cellularia ternata.	C. J. S.	Cellepora scabra.	J. S.
Caberea Ellisii.	C. J. S.	C. ramulosa, var.	C. J. S.

Radiata.

Echinodermata.

Lophothuria Fabricii.	C. J.	Pteraster militaris.	C. J.
*Schizaster fragilis.	C.	Hippasteria phrygiana.	C.
Strongylocentrotus Dröbachiensis.	C. J. S.	Archaster Parelii.	C.
		A. arcticus.	C.
" var. with slender reddish spines.	C. J.	Asterina (?), sp.	C.
		*Ctenodiscus crispatus.	C.
Echinarachnius parma.	S.	Ophiopholis aculeata.	C. J. S.
Asterias vulgaris.	C. J. S.	*Ophioglypha Sarsii.	C. J. S.
Leptasterias tenera.	C. J. S.	*O. robusta.	C. J. S.
L. compta.	C. J. S.	Amphipholis elegans.	J.
L. Mulleri (?)	C.	A. Torelli (?).	C.
Stephanasterias albula.	C. J.	Ophiacantha spinulosa.	C. J. S.
Solaster endeca.	C. J. S.	Astrophyton Agassizii.	S.
Cribrella sanguinolenta.	C. J. S.	Antedon Sarsii.	C.

Hydroida.

Campanularia verticillata.	J. S.	Sertulariella polyzonias, var.	C. J. S.
Obelia, sp.	C. J. S.	S. tricuspidata.	C. J. S.
Grammaria abietina.	C. J.	Eudendrium, sp.	S.
Lafoëa, sp.	S.	Tubularia indivisa.	C. J. S.
Halecium muricatum.	J. S.	*Corymorpha pendula.	J. S.
Diphasia fallax.	C. S.	Hydractinia polyclina.	S.
Sertularia cupressina.	C. J. S.		

Anthozoa.

Alcyonium carneum.	J. S.	Urticina nodosa.	C.
Cornulariella modesta V.	J.	U. crassicornis.	J. S.
*Edwardsia, sp.	C.	Bolocera Tuediæ.	C.

PROTOZOA.

Spongiæ.

Hyalonema longissimum.	C.
Thecophora ibla.	C. J.
Dorvillia echinata V.	C.
Tethya hispida Bowerb.	C. J.
Polymastia robusta (?).	S.
P. mamillaris (?).	J.
Polymastia hispid species.	C. J.
Trichostemma, sp.	J
Suberites (?), bright yellow with large verrucæ.	J.
Suberites, smooth, orange, massive sp.	J.
Cliona, sp.	J.
Globular, cancellated sponge.	J.
Reniera, coarse and open sp.	C. J. S.
Reniera, sp. with conical verrucæ.	J.
Halichondria panicea.	J.
H., sp., dark red, on shells.	C. J. S.
H. (?), sp., purplish, encrusting.	C. J.
Compact branching sponge.	C.
Cup-shaped sponge. with 6-rayed spicula.	C.
Isodictya, sp., with large oscules.	C. S.
I. infundibuliformis (?).	C. S.
Grantia ciliata.	S.
G. arctica (Sycandra Hæckel).	C.

Several other sponges occurred which have not been examined.

The two localities in shallow water, near Salem Harbor, yielded a number of interesting species, with many of the well-known species characteristic of Massachusetts Bay and the adjacent coasts.

EXPLANATION OF PLATES.

Plate VI.—Figure 1, *Vermilia serrula* Stimpson; an immature specimen, much enlarged.

Figure 2, *Praxilla zonalis* Verrill; Casco Bay, 8 to 20 fathoms; anterior and posterior portions, enlarged 4 diameters. This species has 22 setigerous segments, and the circular bands of color on the anterior portion are bright red.

Figure 3, *Ancistria acuta* Verrill, from Casco Bay, 10 to 15 fathoms; enlarged 32 diameters.

Figure 4, *Enipo gracilis* Verrill; setæ, enlarged 175 diameters.

Figure 5, *Amphitrite cirrata; a*, side view, enlarged about 2 diameters; *b*, one of the branchiæ more enlarged; *c*, one of the uncini enlarged 500 diameters.

Plate VII.—Figure 1, *Ophionemertes agilis* Verrill; dorsal view, enlarged four times.

Figure 2, *Macronemertes gigantea* Verrill; *a*, head, dorsal view; *b*, head, ventral view; natural size.

Figure 3, *Tretrastemma vittata* Verrill; *a*, head, dorsal view; *b*, head, front view; enlarged.

Figure 4, *Euchone elegans* Verrill; enlarged.

Figure 5, *Ammotrypane fimbriata* Verrill; ventral view, enlarged.

Figure 6, *Clymenella torquata* Verrill; side view, natural side.

Figure 7, *Urticina nodosa* Verrill (Fabr. sp.); natural size.

Plate VIII.–Figure 1, *Cornulariella modesta* Verrill; enlarged.

Figure 2, The same; spicula of the integument, much enlarged.

Figure 3, *Alcyonium carneum* Ag.; three of the polyps, much enlarged.

Figure 4, *Edwardsia farinacea* Verrill; enlarged about three diameters.

Figure 5, The same; view of the disk; more enlarged.

Figure 6, *Oligotrochus vitreus* Sars; *a*, an immature plate; *b*, a fully developed one; enlarged 140 diameters.

Figure 7, *Scalpellum Stroëmi* Sars; side view, enlarged 5 diameters.

Figure 8, *Thecophora ibla* W. Thompson; natural size.

[Figure 4 of plate VI, figures 2 and 4, plate VIII, and figures 1 to 6 of plate VII were drawn by the author; figure 7 of plate VIII, by S. I. Smith; figure 8, plate VIII, by Mr. Sherman; figure 5 of plate VI was copied from Malmgren; all the rest were drawn by J. H. Emerton.]

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Specific Heats of Zirconium, Silicon and Boron.*—W. G. MIXTER and E. S. DANA have determined with great care, in Bunsen's laboratory, the specific heats of zirconium, of silicon and of boron, with a view to fix the atomic weight of zirconium and consequently the formula of zirconia. Although this earth forms salts with acids, yet Marignac's discovery of the isomorphism of zirconium fluoride with the fluorides of silicon, of titanium and of tin, has resulted in giving the formula ZrO_2 to zirconia, instead of ZrO or Zr_2O_3. The specific heat determinations were made with the original ice-calorimeter of Bunsen.* In order to become familiar with the use of the apparatus, some preliminary experiments were made with chemically pure cast silver and with crystallized silicon. The constants of the apparatus were W_w, W_p, and W_g; representing respectively in divisions of the scale on the instrument the quantity of heat evolved by one gram of water, platinum and the glass used, when cooled from 1° to 0° C. These values were as follows: $W_w=14{\cdot}657$; $W_p=0{\cdot}4692$; $W_g=2{\cdot}7657$. The results of the preliminary experiments are given in the following table:

		Silver.	Silicon.	Silicon.
Weight of substance	G,	4·1415	1·0011	1·0011
Weight of glass case	G_g,	0	0·2014	0·2014
Weight of platinum load	G_p,	0	0·4374	0·4374
Temperature of expt.	t,	99·3°	99·45°	99·45°
Duration of experiment	M_1-M_0,	40′	20′	45′
Scale motion before expt.,	$\frac{t_0}{M_0}$,	+0·02	+0·236	+0·169
" " after "	$\frac{t_1}{M_1}$,	+0·163	+0·327	+0·151
Oscillation of scale	$Q-Q_1$,	327·5	317·6	317·3
Corrected movement	T,	331·16	323·23	324·5
Specific heat	S,	0·05494	0·16995	0·1704

The value thus found for the specific heat of silver, 0·0549, agrees very well with that obtained by Bunsen, 0·0559, and is less than that given by Regnault, 0·0570. For silicon, different specimens gave Regnault values varying between 0·166 and 0·180. In order to ascertain the purity of their specimen, which consisted of large well-formed crystals showing no mechanically-mixed impurities, the authors heated a portion of it in a stream of chlorine gas, and determined the silicon from the loss. It contained silicon 98·7, iron 0·6, zinc 0·7=100. Correcting the observed specific heat by this analysis, they obtained 0·1710 for the true specific heat of silicon, and (14·2×0·1710) 2·429 for its atomic heat; thus confirming the deviation of this element, even when pure, from the law of Dulong and Petit.

* This Journal, III, i, 172, 271, 348, 1874.

For the zirconium determinations, a material was used which, as shown by analysis, consisted of zirconium 54·53, silicon 5·44, aluminum 40·36 = 100·33. It was homogeneous in appearance and was made up of metallic scales resembling graphite. It gave as follows:

		I.	II.
Weight of substance, ----------	G,	1·3019	1·3019
Weight of glass case, --------	G_g,	0·1781	0·1781
Temperature of the expt., -----	t,	99·7°	99·75°
Duration of the expt.,	$M_1 - M_0$,	30′	35′
Scale-motion before expt., ----	$\frac{t_0}{M_0}$,	+0·137	+0·111
Scale-motion after expt., -----	$\frac{t_1}{M_1}$,	+0·18	+0·14
Oscillation during expt., -----	$Q - Q_1$,	294·1	296·2
Corrected scale-motion, ------	T,	298·85	300·59
Specific heat, --------------	S,	0·1313	0·1321

Correcting this result by the analysis above given, the authors find for the specific heat of pure zirconium the value 0·6666, and for its atomic heat, 2·986. This last number agrees well with that of silver, 2·968, and confirms the formula ZrO_2 as the correct expression for zirconia.

The boron, whose specific heat was determined by Mixter and Dana, consisted for the most part of well-formed crystals, having the following composition: Boron 90·18, aluminum 9·82 = 100. The specific heat of this substance, as obtained in two determinations, is given as 0·2472 and 0·2489. Calling the specific heat of aluminum 0·2143, the specific heat of pure boron becomes 0·2518, and its atomic heat 2·745; or, taking its atomic weight at 5·45, to bring it into accordance with the other determinations, 1·3725; thus confirming the results of Regnault and Kopp, and giving a much smaller number than is required by Dulong and Petit's law. —*Ann. Chem. Pharm.*, clxix, 388, Oct., 1873. G. F. B.

2. *On a constant Normal Flame.*—The necessities of practical photometry as well as exact scientific research require the use of a normal flame constant in character and uniform in results. This is far from being the case either with the generally used standard candle, the carcel lamp of definite form and size as used in France, or the pure ethylene gas flame used in Germany. WARTHA proposes therefore a simple apparatus by which he hopes to attain this desideratum; as employed in his preliminary experiments, it consists of an ordinary gun-metal cylinder, such as is used for containing the liquid carbonic acid in a Natterer's condensing pump, placed in a tin outer vessel filled with water. To the jet is affixed a gas burner, just below which is placed a small water manometer. This cylinder is filled nearly full with ordinary ether, and the water outside of it is heated to boiling. The pressure in the interior of the cylinder is, according to Regnault's experiments, 4950·81$^{mm.}$ and will remain constant for an hour. If now the fine screw be opened slightly, the ether vapor passes, under only three or four millimeters of water pressure, to the burner, and, being ignited, burns with a brilliant white flame resembling

that of gas. It is easy to see that an apparatus can be constructed weighing only from 100 to 150 grams, which will sustain, under the conditions above given, double the required pressure, and which can be placed on the balance and its consumption obtained within a milligram. If a burner with an opening of known diameter be used, and the estimation be made, as is now common with the standard candle, by noting the height of the flame, and the number of the divisions the key is turned, the character of the flame and the consumption of material may be absolutely controlled and registered. The author suggests the use of this apparatus for determining vapor tensions, especially of the more dangerous burning oils.—*Ber. Berl. Chem. Ges.*, vii, 103, Feb., 1874.

G. F. B.

3. *On the so-called Continuing Rays of Becquerel.*—In 1843, Becquerel stated that, if silver chloride be exposed to the spectrum directly, it begins to be blackened first in the outer violet rays, the action subsequently extending up to the line F. But if, previous to this exposure, diffused light be allowed to fall upon it long enough to permit a very feeble action to take place, then, when exposed to the spectrum, not only does the blackening take place in the outer violet, but throughout the whole spectrum even to the outer red. He hence called the violet the exciting rays, and the others continuing rays, because they appeared to continue the action when it was once commenced by the violet. These experiments were made with the chloride of silver, and it is upon this substance that his theory is founded. Though he used the iodide and bromide, yet, as they were not pure, he was misled. Though this theory of Becquerel has been contested by Draper, Claudet, Gaudin and others, yet as Guetzlaff has recently revived it in the recommendation to under-expose photographic plates in the camera, and then to give them a supplementary exposure behind red glass (or any glass which transmits no blue rays); H. VOGEL, in connection with Zencker and Prumm, has re-examined the question. The results prove that, with the ordinary silver iodide and bromide process, exposure behind a red glass has no effect whatever. Vogel hence explains the apparent continuing action in the case of silver chloride as special, due to the following facts: 1st, that pure white silver chloride ($AgCl$) is sensitive only for violet and ultra-violet rays, being by them reduced to the violet argentous chloride (Ag_2Cl); 2d, that this violet chloride, as proved by the experiments of Seebeck, Herschel, Poitevin, Zencker, and others, is sensitive for almost all the colors of the spectrum; a fact of great significance in color photography. Becquerel therefore obtained an effect from all parts of the spectrum because he used this violet chloride, produced by his preliminary exposure. In proof of this, the violet chloride produced by purely chemical processes without the aid of light, is shown to be sensitive to the red and yellow rays. That the trace of argentous chloride produced by the brief preliminary exposure can result in so intense a darkening Vogel thus explains: 1st, the violet chloride is reduced to metallic silver by the light:

$$Ag_2Cl = Ag_2 + Cl.$$

2d, in presence of the white chloride, this metallic silver reacts to give the violet body:

$$AgCl + Ag = Ag_2Cl.$$

This is then reduced as before, and the process goes on till all the silver chloride is decomposed. It is therefore evident that, in the sense in which Becquerel used the term, there is no such thing as "continuing" rays. When light-rays which are themselves inactive appear to continue the action of those which are active, the fact is to be ascribed to the production, by the active rays, of a new compound, decomposable now by the previously inactive rays. Chloride of silver shows this action best, because of the intensity of its color-changes. Since, however, the color of argentous chloride is violet, the complementary colors red, yellow and green must be absorbed; and since it is the absorbed rays which produce actinic effects, it is to be expected that the violet chloride will be sensitive to the so-called inactive rays. Moreover, silver bromide being itself directly sensitive to the rays of low refrangibility, it cannot evidently exhibit this continuing action. And, since both bromide and iodide are colored yellow by light, they are not more sensitive to yellow on subsequent exposure, because they do not absorb it.—*Ber. Berl. Chem. Ges.*, vi, 1498, Jan., 1874. G. F. B.

4. *On the Solubility of Arsenous Oxide.*—Of the two modifications of arsenous oxide, the vitreous or transparent and the porcelain-like or opake, the former is well known to be more soluble in water than the latter. STELZER, under the direction of Buchner, has made a series of experiments with a view to determine the exact solubility of these varieties. The oxide was prepared in the second of the above modifications, by solution in hot dilute hydrochloric acid, and slow cooling of the filtrate. The octahedral crystals were washed, dried and pulverized. The estimation of the amount dissolved was effected by titrition with a tenth-normal solution of iodine, being controlled by evaporation and direct weighing. A portion of this acid was placed in a flask, and treated with pure water at 15° C., for twenty four hours. Every 100 c. c. of this solution contained 0·28215 grm., and every liter 2·8215 grams of the crystalline oxide. A second portion was then heated with distilled water to 100°, and the solution kept boiling for 20 minutes. It was cooled to 15°, allowed to stand 24 hours, and filtered; on analysis each 100 c. c. contained 2·1873 grams, and one liter 21·873 grams, a quantity nearly eight times greater than in the first experiment. Such a difference can only be explained on the hypothesis that during the boiling a molecular change takes place, resulting in the conversion of the crystalline into the amorphous form. Upon testing the amorphous variety, prepared by heating the pulverized crystals in a flask, to a high temperature, it was found that water which had been agitated, upon the oxide at 15° for 24 hours, contained 0·9306 grm. in 100 c. c., and 9·306 grms. in one liter. Finally, the amorphous oxide

was boiled with water for several minutes, the mixture cooled to 15° and allowed to stand 24 hours. The filtered solution contained 3·4056 grams, the liter 34·056 grams of this variety. The difference in solubility at 15° of the two forms is consequently much greater than at 100°. One part of the crystallized oxide requires at 15°, 355, one part of the amorphous at 15° requires 108 parts; one part of the crystallized at 100° requires 46 parts, and one part of the amorphous at 100° requires 30 parts of water for solution.—*J. pr. Ch.*, II, viii, 234, Dec., 1873. G. F. B.

5. *On the Constitution of Anthracene.*—Two views are held upon the constitution of anthracene; one that its two CH groups are united directly together and then are united to the two benzol nuclei; the other that these groups are united to these nuclei separately. The former view would make anthracene belong to the 1 : 4 or para series and may be formulated thus:

$C_6H_4 \left\{ \begin{matrix} CHCH \\ \overline{\qquad} \end{matrix} \right\} C_6H_4$; the latter regards anthracene as a 1:2 or ortho-derivative, which may be thus written: $C_6H_4 \left\{ \begin{matrix} CH \\ \dot{C}H \end{matrix} \right\} C_6H_4$.

For the former view, the fact is urged that solid tolyl-phenyl-ketone heated with soda-lime, yields paratoluic acid and benzol, and hence belongs to the para-series. But, since this ketone gives the same benzoyl-benzoic acid on oxidation as benzyl-toluol, it follows that this latter body, and consequently the anthracene, which is derived from it by the action of heat, belongs to the para-series. Finding that the solid tolyl-phenyl-ketone did not afford anthracene, Behr and Van Dorp were led to suspect the existence of two isomeric benzyl-toluols, one of which afforded the anthracene, while the other gave the para-benzoyl-benzoic acid. They consequently prepared the two tolyl-phenyl-ketones and submitted them to investigation. The liquid ketone afforded, on oxidation with chromic acid, beside some para-benzoyl-benzoic acid, the β-benzoyl-benzoic acid of Zincke. Oxidation with manganese dioxide and sulphuric acid gave in addition anthraquinone. The solid ketone gave only para-benzoyl-benzoic acid in both cases. The liquid ketone passed over ignited zinc dust yields β-benzyl-toluol, which then condenses to anthracene; while the solid ketone thus treated gave an oil boiling at 285°, having the composition of benzyl-toluol and affording para-benzoyl-benzoic acid on oxidation. It is therefore para-benzyl-toluol. It affords no anthracene on passing its vapor through a red-hot tube. Hence Behr and Van Dorp regard their suspicion as established, and believe that anthracene cannot be a para-derivative of benzol. They, however, regard it as a 1 : 2 or ortho-derivative, and assign to it the second of the above formulas.—*Ber. Berl. Chem. Ges.*, vii, 16, Jan., 1874.

G. F. B.

6. *On a new Amyl Alcohol.*—Backhoven has obtained a dextro-rotatory amyl alcohol from fusel oil. The following are the conclusions of his paper: (1) When, from commercial fusel oil, amyl-sulphuric acid is prepared by means of oil of vitriol, and

this is converted into barium amyl-sulphate, the kind of salt obtained is determined by (A) the quantity of sulphuric acid added, and (B) the temperature of the mixture. (2) With unequal quantities of alcohol and sulphuric acid, a portion of the amyl-sulphuric acid, mixed with decomposition products, separates out as an oily liquid. This, when washed with water and neutralized, gives salts which in their rotatory power are different from those obtained from the amyl-sulphuric acid which the water has dissolved. In this way, not only a lævo-, but also a dextro-active salt is obtained, and also the corresponding alcohols. The composition of these salts is the same. (3) Distillation of commercial amyl alcohol with sodium hydrate in excess gives an optically active dextro-rotatory alcohol. (4) The rotatory power of the radical C_5H_{11} is in barium amyl-sulphate five times as great as under otherwise equal conditions it is in the alcohol prepared from these salts.—*J. pr. Ch.*, II, viii, 272. G. F. B.

7. *A new Synthesis of Alcohols.*—WAGNER and SAYTZEFF have obtained an amyl alcohol by the action of a mixture of ethyl iodide and zinc upon ethyl formate. Judging from the mode of its formation, they consider it to be a secondary alcohol, probably diethyl carbinol $C\begin{cases}C_2H_5\\C_2H_5\\H\\OH\end{cases}$. They are at present engaged in studying this product and also the products obtained by employing the iodides of the other alcohol radicals. They are investigating, in addition, the action of the organic zinc compounds on the ethers of the fatty series generally.—*Ber. Berl. Chem. Ges.*, vi, 1542, Jan., 1874. G. F. B.

8. *On Coerulignone.*—About a year ago, Liebermann discovered a remarkable blue substance under the above name, obtained from the crude pyroligneous acid of beech wood. As it yielded a colorless crystalline body on reduction, he suggested that it was derived from this body, probably a phenol, existing in the acid. HOFMANN has recently confirmed this prevision. Having received some of the last portions of the distillate of beech wood naphtha, in the form of a brown oil, he separated from it a colorless liquid boiling at 270°, having a strong creosote odor and giving crystalline salts with the fixed alkalies and with ammonia. In contact with potassium dichromate, it at first turned brown, and then solidified to a mass of violet crystals, having all the properties of coerulignone. An analysis of the crystals gave for them the formula $C_{16}H_{16}O_6$. Further researches upon it are in progress.—*Ber. Berl. Chem. Ges.*, vii, 78, Jan., 1874. G. F. B.

9. *Elongations due to Electricity.*—Mr. H. STREINTZ has conducted a series of experiments on the change of length of bars of various metals, when traversed by electric currents. The change in length is measured by levers and mirrors, in which the reflection of a graduated scale is viewed with a telescope. To eliminate the effect due to the increase of temperature produced by the

current, the bar was covered with stearine, and the strength of the battery so adjusted that the point of fusion should be just attained. The current was then broken and the measurement repeated at the same temperature by immersing the wire in a bath of melted stearine. From these observations he obtains the following conclusions:—

1st. The galvanic current produces no other modification in the elasticity of a conducting wire than that due to the elevation of temperature produced.

2d. Under the action of the current, the conductor expands more than when it is brought to the same temperature without the current; tempered steel alone forms an exception to the rule.

3d. The galvanic dilatation does not show itself at the very instant when the current is closed, but gradually, like the expansion produced by heat.

4th. The galvanic dilatation does not appear to be the consequence of an electro-dynamic repulsion, but results rather from a heat polarization or change of plane (*orientation*) of the vibrations of heat.

The ratio of the expansions produced by heat and electricity equals for platinum, ·25; for copper, ·15; for soft iron, ·22; for hard iron, ·13; and for hardened steel, in one case −·01.—*Bibl. Univ.*, 194, p. 143. E. C. P.

10. *Selenium Photometer.*—The Earl of Rosse has made some experiments on the changes which take place in the electrical resistance of selenium, when exposed to light, to see how far these variations may be due to changes of temperature. He exposed a bar of selenium to the light of a candle, at a distance of four inches, and found its resistance diminished 24 per cent. A vessel of hot water nine inches in diameter, and placed at a distance of seven inches, produced no perceptible effect. On the other hand, a thermopile and Thomson's galvanometer gave in the first case a deflection of 315 divisions, and in the second 136, when the water was thirteen inches distant. The effect of the candle on the flame was next determined when a plate of glass was interposed; the effect was slight, the diminution in resistance being 90 per cent of what it was before. The thermopile, on the other hand, showed that but 48 per cent was transmitted. A solution of alum interposed in the same way gave 95 per cent by the selenium, and only 7 per cent by the thermopile. Having thus shown the comparative if not absolute insensibility of selenium to radiant heat of low refrangibility, and that therefore it could not replace the thermopile, he proceeded to determine the law of the change in resistance with variations of the light. In the following table the columns marked I. give the distance of the light in inches; those marked D. the corresponding decrease in resistance in percentages.

I.	D.	I.	D.
2·5	38	19	11
5·	27	22·5	10
7·	22	44·5	3·8
9·	21	75	1·6
13·5	15		

The presence of moisture rendered the effect feeble and uncertain, probably owing to the deposit of a very slight film of moisture on the surface of the bar.—*Phil. Mag.*, xlvii, 161. E. C. P.

11. *Acoustic Transparency and Opacity of the Atmosphere.*—Prof. TYNDALL, in a recent lecture at the Royal Institution, describes some experiments on the comparative ease with which sounds are transmitted through the air on different days. Various sounds were employed, large trumpets or horns sounded by steel reeds, whistles like those of a locomotive, and cannon. The observers on board of a steamer moved to and fro until the limit of audibility was reached. The following are a portion of the results obtained.

May 19th. Wind strong. At two miles the whistles became so faint as to be useless as fog-signals; at three miles the same was true of the horns; at four miles neither could be heard.

May 20th. At three miles whistles inaudible; faint sound of horn heard at six miles. Going out a little further, an 18–pounder was fired with a three pound charge, and was distinctly heard. Even at 9·7 miles a similar sound was faintly audible. This would seem to prove the complete superiority of cannon over horns as fog-signals; but on other days this result was completely reversed.

June 3rd was dark and threatening, with a faint haze in the air, but the horns were audible at nine miles. A heavy rain-shower approached, but its presence produced no effect on the sounds.

July 3rd was a lovely morning, with the air calm and sea smooth. At 3¾ miles nothing was heard; at two miles the howitzer and mortar were barely audible, and the 18–pounder unheard. In the afternoon a cloud covered the sun, when at 3¾ miles the guns were faintly audible. As it grew later, the sounds became more audible, so that at 7¾ miles they were easily heard. The master of the Varne lightship, 12¾ miles distant, after 5 P. M. heard the sounds, even the whistles, distinctly. Accordingly at 12 miles the sounds were more audible in the evening than at two miles in the day; the mere presence of a cloud and lowering of the sun, increased the acoustic transparency of the atmosphere forty times.

The explanation of these curious effects is found in the observations of Humboldt at the Falls of the Orinoco, which he found three times louder by night than by day, notwithstanding the greater noise of beasts and insects at that time. He accounted for it by the unequal density of the air, caused by the heating of the rocks scattered over the plain between him and the falls. He found that the rocks became 30° hotter than the surrounding grass, and hence formed the base of a column of hot air, from the surface of which continual reflections of the sound-wave took place. In the same way, at sea the heat of the sun produced copious evaporation and the vapor in rising would mix irregularly with the air, which would reflect the sound like the columns of hot air.

It thus appears that on a perfectly calm day a stratum of air three miles thick is capable of stifling both the cannonade and fog sounds. All the observations point to the mixture of air and aqueous vapor as the cause which could fill the air with an *acoustic cloud* on a day of the most perfect optical transparency. If this explanation is correct, the sound cut off by the vapor should be reflected, thus producing an echo, a result fully verified by observation. Still more marked effects were obtained with a Brown's steam syren. The morning of October 8th was remarkably clear at 5¼ miles the horns were heard feebly, the syren clearly. In the afternoon it clouded up, rained and hailed with almost tropical violence. In the midst of this furious squall both horn and syren were heard, and when the shower lightened, thus lessening the local pattering, the sounds so increased that at 7½ miles they were more audible than before the shower at five miles. This observa- is utterly opposed to the statement of Durham and others, regarding the stifling influence of falling rain on sound.

On Dec. 10th, during a dense fog, some experiments were made in London of a similar nature. Sounds were then heard at double the distance, as distinctly as on Dec. 13th, when the fog was replaced by a slight haze.

Finally, to imitate these effects experimentally, an instrument was devised by Mr. Cottrell, consisting of a long box through which 25 sheets of coal gas could be made to ascend, and between them descending films of carbonic acid. At one end of the box was placed an electric ball in a padded box, with a single opening in it. At the other end was a funnel with a sensitive flame opposite its small end. When the box contained air only, at each stroke of the bell the flame responded, so that its length was greatly lessened and emitted a musical roar when the bell sounded continually. When now the gases were admitted, the sound was completely cut off by reflection from the interposed surfaces, so that the flame remained perfectly tranquil.—*Nature*, ix, 251, 267. E. C. P.

12. *Reflection of Sound by Flame.*—Mr. Cottrell has recently performed some experiments of the division of sound by a layer of flame or heated gas into a reflected and transmitted portion. A vibrating bell contained in a padded box was directed so as to propagate a sound-wave through a tin tube, and its action rendered manifest by its causing a sensitive flame, placed at a distance in the direction of the sound-wave, to become violently agitated.

The invisible heated layer immediately above the luminous portion of an ignited coal-gas flame, issuing from an ordinary batswing burner, was allowed to stream upward across the end of the tin tube from which the sound-wave issues. A portion of the sound-wave issuing from the latter was reflected at the limiting surfaces of the heated layer; and a part being transmitted through it was now only competent to slightly agitate the sensitive flame.

The heated layer was then placed at such an angle that the reflected portion of the sound-wave was sent through a second tin tube (of the same dimensions as the above), and its action rendered visible by its causing a second sensitive flame, placed at the end of the tube, to become violently affected. This action continued so long as the heated layer intervened; but upon its withdrawal, the first mentioned sensitive flame, receiving the whole of the direct pulse, became again violently agitated, and at the same moment the second sensitive flame, ceasing to be affected, returned to its former tranquility.—*Nature*, ix, 334. E. C. P.

II. Geology and Natural History.

1. *On Mountain Sculpture in the Sierra Nevada, and the method of glacial erosion;* by E S. Carr.—After speaking of the divisional planes in the granites of the Sierra Nevada, Prof. Carr remarks as follows.—The greatest check to the free play and controlling power of these divisional planes is the occurrence, in immense numbers and size, of domes, cones, and round wave-ridges, together with an innumerable brood of modified forms and combinations. The curved cleavage which measures and determines these rounded forms may be designated *the dome cleavage*, inasmuch as the dome is apparently the most perfect typical form of the group.

Domes of close-grained siliceous granite are admirably calculated to withstand the action of atmospheric and mechanical forces. No other rock-form can compare with it in strength; no other offered so unflinching a resistance to the tremendous pressure of the glaciers. A dam of noble domes extends across the head of Yosemite Valley, from Mount Starr-King to North Dome, which was effectually broken through by the combined force of the Hoffman and Tenaya glaciers; but the great South Lyell glacier, which entered the valley between Starr King and Half Dome, was unable to force the mighty barrier, and the approach of the long summer which terminated the glacial epoch found it still mazing and [illegible]dging compliantly among the strong unflinching bosses, just as the [illegible]ds are compelled to do at the present time.

The Starr King group of domes is perhaps the most interesting of the Merced basin. The beautiful conoid, Starr King, the loftiest and most perfect of the group, was one of the first to emerge from the Glacial sea. * * *

There appear to be no positive limits to the extent of dome structure in the granites of the Sierra, when considered in all its numerous modifications. Rudimentary domes exist everywhere, waiting their development, to as great a depth as observation can reach. The western flank was formerly covered with slates, which have evidently been carried off by glacial denudation from the middle and upper regions; small patches existing on the summits and spurs of the Hoffman and Merced Mountains are all that are now left. When a depth of two or three thousand feet below the bottom of the slates is reached, the dome structure prevails almost to the exclusion of others. As we proceed southward or northward along the chain from the region adjacent to Yosemite Valley, dome forms gradually become less perfect. * * *

Glacial erosion.—No matter how abundant the glacial force, *a vertical precipice can not be produced unless its cleavage be vertical*, nor a dome without dome structure in the rock acted upon. Therefore, when we say that the glacial ice-sheet and separate glaciers *molded* the mountains, we must remember that their molding power upon *hard granite possessing a strong physical structure* is comparatively slight. In such hard, strongly built granite regions, *glaciers do not so much mold and shape as disinter forms already conceived and ripe.* The harder the rock, and the better its specialized cleavage planes are developed, the greater will be the degree of controlling power possessed by it over its own forms, as compared with that of the disinterring glacier; and the softer the rock and more generally developed its cleavage planes, the less able will it be to resist ice action and maintain its own forms. In general, the *grain of a rock determines its surface forms;* yet it would matter but little what the grain might be—straight, curved, or knotty—if the excavating and sculpturing tool were sharp, because in that case it would cut without reference to the grain. Every carpenter knows that only a dull tool will follow the grain of wood. Such a tool is the glacier, gliding with tremendous pressure past splitting precipices and smooth-swelling domes, flexible as the wind, yet hard-tempered as steel. Mighty as its effects appear to us, it has only developed the predestined forms of mountain beauty which were ready and waiting to receive the baptism of light.—*Overland Monthly*, May, 1874.

2. *Note on the recent Volcanic Action in Hawaii;* by T. Coan, from a letter to J. D. Dana, dated Hilo, Hawaii, Jan. 6th, 1874.—You are aware that the great summit crater of Mauna Loa, Mokuaweoweo, has, for a number of years, shown but few and feeble symptoms of activity, until the past year. For a few days in August, 1872, there was a brilliant light in the crater; and again on the 6th and 7th of Jan., 1873, there were vivid demonstrations, which roused the attention of many witnesses. But it was not until the 20th of April, 1873, that a continuous exhibition of mountain pyrotechnics commenced. From that day to the present, now almost nine months, the action within the great cauldron has not remitted. Most of the time the boiling has been vehement, and the scene was never more brilliant than a few nights ago. Sustained jets of molten-rock were constantly rising 50 to 200 feet within the mural caldron, and the surgings, puffings and roarings have been heard low down the sides of the mountain, and, as some testify, as far as Reed's Ranch, probably fifteen miles.

But the great marvel of this eruption is its *duration.* We have seen nothing like it before in this crater. The eruption of 1855–6 flowed fifteen months; but this rent the mountain laterally and flowed longitudinally; whereas the present eruption has, as far as we know, made no lateral vent and found no outlet. The action is vertical, and it is simply a gigantic mountain-pot of boiling lavas.

Can you tell what sustains these Plutonic fires, and lifts those burning columns and agitates that fiery abyss at the height of nearly 14,000 feet? What are the forces which move or shake with so terrific power the foundations beneath us?

Kilauea, during all this time, has been unequally active. Sometimes the action has been intense and the illuminations brilliant; and again Madam Pele has been quiet.

But the great depression in Kilauea, caused by the eruption of 1868, is fast filling up by repeated overflows from the south lake, while, all around that lake, a vast mound is rising, whose summit is nearly as high as the southern rim of Kilauea, and it may soon overlook it.

3. *On the Mineral resources and Geology of the State of Queretaro, Mexico;* by SEÑOR MARIANO BARCENA. A memoir (in Spanish) presented to the Director of the School of Engineers, Mexico, and published under the direction of the Minister of Justice and Public Instruction. 28 pp. 4to. Mexico. 1873.—After describing the mineral localities of Queretaro, which include mines of gold, cinnabar, native silver and tetrahedrite, galena and manganese ore, besides the opals mentioned in a former number of this Journal, Señor Barcena in his valuable memoir treats of the geology and physical geography of the State. He distinguishes three formations, the Cretaceous, Tertiary and Quaternary. The Cretaceous extends across the State from east to west, and contains fossils of the genera Crania, Hippurites, Nerinæa, and other Cretaceous forms. The occurrence of these Cretaceous beds shows that the region of the Sierra Gorda was submerged during that period. The trachytic rocks of the State belong for the most part to the Tertiary period.

Remains of the Mastodon and Elephant occur in the Quaternary of the valleys. Following the geological chapters are others on the Archæology, Flora and Fauna, Statistics and History of the State.

It is much to be desired that the work ,which Señor Barcena has so ably performed for Queretaro, should be extended by others over all the Mexican States.

4. *Report of Progress of the Geological Survey of Canada, for* 1872–1873*;* ALFRED C. SELWYN, F.G.S., Director. 300 pp. 8vo. Montreal, 1873. (Dawson Bros.)—This volume contains Reports by Mr. Selwyn, the Director of the Survey, J. Richardson, Dr. Dawson, Mr. E. Billings, Dr. Harrington, Mr. Robert Bell, Mr. McQuat, Mr. H. G. Vennor; on part of New Brunswick, by Prof. Bailey and Mr. Matthew; on the coal mines of Cape Breton by Mr. Charles Robb. Mr. Selwyn, in his notes on a Geological Reconnaisance from Lake Superior to Fort Garry, remarks respect-

ing the so-called (on lithogical grounds) Huronian Rocks observed on the route between Lac des Mille Lacs and Separation Lake, and thence *via* Sandy Lake to the Lake of the Woods, resemble as closely the chloritic, epidotic, and dioritic strata of the *altered Quebec group* as they do those which on the shores of Lakes Huron and Superior are referred to the Huronian series; and that a similar series of rocks about Lakes Mistassini and Abbitibbe, overlying the Laurentian gneiss (like the others), are also probably of the Quebec group. Mr. Billings found that the Mistassini serpentinous limestones contain corals related to Tetradium; and the rocks of Abbitibbe are so closely like those of the former place that they are probably of the same formation. This being so, Mr. Selwyn remarks that "it becomes an interesting question in what way they are related to the Huronian series of Lakes Huron and Superior."

The report by Mr. Richardson, with those on the fossils of the coal beds of Vancouver's Island and vicinity, are of great interest. Mr. Richardson states that on Vancouver's Island the productive Coal-measures, (1) 939½ feet thick, are overlaid by (2) lower shales, 1000 feet in thickness; (3) lower conglomerate, 900 feet; (4) middle shales, 76 feet; (5) middle conglomerate, 1100 feet; (6) upper shales, 776 feet; (7) upper conglomerate, 320 feet. Numbers 2 and 4 contain *Ammonites*, *Baculites*, *Inocerami* and other Cretaceous species; and numbers 6 and 7 contain *Belemites.*

5. *Texas Geological Survey.*—The State of Texas has ordered a Geological and Agricultural Survey, placing it in charge of Prof. S. B. Buckley. Prof. Buckley has appointed Prof. Cousins as chemist of the survey, Prof. Burleson as first assistant geologist, and Mr. C. E. Hall, son of Prof. James Hall, as assistant in the paleontological department.

6. *Annual Report of the State Geologist of New Jersey for the year* 1873.—This Report on the progress of the Survey during the past year consists largely of various matters of economic importance, such as the drainage of some tracts of land on the Passaic and Pequest Rivers. Its chief geological interest lies in the description of the Archæan rocks and the mines of magnetic iron ore occurring in them. The Archæan region is subdivided into four belts running across the northern part of the State in a northeasterly direction (strike N. 43° E.). The prevailing rock is a syenitic gneiss, either vertical or dipping to the southeast, with white crystalline limestone occurring largely in the Passaic and Pequest belts (the first and fourth from the south). Especial attention has been devoted to the iron mines, upward of 150 of which are described, some of them with considerable detail; numerous analyses of the ore add to the value of the rest. A well executed map in two sheets represents clearly the four belts of Archæan alluded to, and is particularly interesting as giving a good idea of the relative positions and number of the outcrops of iron ore.

7. *Petrographische Studien an den Basaltgesteinen Böhmens;* Dr. E. Boricky. Prag., 1873 (Arbeiten der geolog. Abtheilung der

Landesdurchforschung von Böhmen, II Th.).—The researches of Boricky extend over the whole range of basaltic eruptions in northern Bohemia, embracing some 300 localities. The memoir contains descriptions of all the important varieties, based upon an examination of 800 microscopic sections, and these are supplemented by eight beautiful colored plates representing sections of crystals and similar matters. The chemical side of the subject has also received due attention, as the large number of analyses show, and in addition to this many other matters of interest are discussed. One of the most interesting chapters is upon the Paragenesis of the secondary minerals of the basalts.

The author distinguishes the following varieties of the basalts: I, Magmabasalt; II, Nephelinbasalt; III, Leucitbasalt; IV, Feldsparbasalt; V, Trachybasalt; VI, Tacylybasalt.

8. *Ueber die Verbreitung des Kali und der Phosphorsäure in den Gesteinen Böhmens*, Dr. E. Boricky. Prag., 1872.—The author gives a considerable number of analyses of the different classes of rocks in Bohemia, and discusses their relation to agricultural matters through the potash, or phosphoric acid, contained.

9. *Das Elbthalgebirge in Sachsen;* von Dr. H. B. Geinitz.—The fourth volume of the second part of this great work has just been published. It contains the Foraminifera, Bryozoans, and Ostracoids of the Pläner, by Dr. Aug. Ritter von Reuss. The text is accompanied by nine plates.

10. *Proceedings of the California Academy of Sciences.*—The first volume of the Proceedings of the Academy, containing a number of valuable original papers, has been reprinted, and a complete series of the publications of the Academy may now be had.

11. *On Unakyte, an epidotic rock from the Unaka range, on the borders of Tennessee and North Carolina;* by F. H. Bradley. (Communicated.)—This name is proposed for a member of the granitic series, from the Great Smoky Mountains, a portion of the *Unaka* range of the Blue Ridge, which range forms the boundary between Tennessee and North Carolina. The specimens thus far seen are from the slopes of the peaks known as "The Bluff," "Walnut Mountain," and "Max's Patch," in Cocke County, Tenn., and Madison County, N. C. The rock is said to occur also in Yancey County, N. C., but in a comparatively inaccessible region.

The character relied upon for the separation of the species is the constant replacement of the *mica* of common granite, or the *hornblende* of syenite, by *epidote.* The amount of this ingredient present is quite variable, in some cases even exceeding one-half of the whole mass. The feldspar present is orthoclase, of various shades of pink, forming from one-fourth to perhaps one-third of the whole. The quartz is mainly white, but occasionally smoky: its isolated portions form but a small part, say one-fourth, of the mass: it is veined in structure, but this is probably not a constant character. Small grains of magnetite are scattered through the rock, but not so thickly as in many granites. No other ingredients have as yet been detected. Mr. G. W. Hawes has determined the specific gravity at 2·79. The rock is very compact and takes a high polish, and will doubtless prove to be a valuable material for ornamental architecture.

The deep weathering of all the rocks of the Southern Appalachians has caused the covering of most of these mountain slopes with deep beds of debris, which conceal most of the solid outcrops; and the dimensions of the bodies of unakyte are therefore as yet unknown. Apparently forming part of the same series, there are heavy beds of specular iron-ore; and the whole series is referred with little doubt to the Archæan age.

12. *Analysis of "Novaculite," or "Ouachita Whetstone," from Hot Springs, Arkansas;* by Mr. C. E. WAIT.—A very pure, snowy-white specimen of this beautiful material, which has been fairly described by Dr. D. D. Owen in his "Second Geological Report on the State of Arkansas," as "equal in whiteness, closeness of texture, and subdued waxy luster, to the most compact forms and white varieties of Carrara marble," of sp. gr. 2·649, proved to consist of: Silica 99·635 (by diff.), alumina 0·113, magnesia 0·087, sodium oxide 0·165, potassium oxide, trace; iron, trace = 100·000. The silica, or at any rate nearly all of it, appears to be in the crypto-crystalline, not in the amorphous or opaline form, as on boiling for three minutes with a twenty per cent solution of sodium hydrate but 1·63 per cent of the mineral was dissolved, and thirty minutes' boiling only led to 3·56 per cent being taken up. —*From Notes of work by Students of Practical Chemistry, in the Laboratory of the University of Virginia, Chemical News, Nov.* 29, 1873.

13. *Note on Pickeringite from Missouri,* (in a letter to one of the editors, from G. C. BROADHEAD, State Geologist of Missouri, dated St. Louis, Mo., March 3, 1874.)—The Pickeringite occurs in efflorescences on sandstone of the Lower Coal-measures in Barton County, Mo. An analysis by the chemist of the Geological Survey, Mr. R. Chauvenet, gives the following for its composition: Sulphuric acid 33·77, alumina 16·58, magnesia 2·92, water 44·64 = 99·91. This nearly corresponds with the composition given for "Pickeringite" on page 653 of Dana's Mineralogy.

14. *Synopsis of the Flora of Colorado;* by THOMAS C. PORTER and JOHN M. COULTER. Washington, March 20, 1874. 8vo, pp. 180.—A prefatory note by Dr. F. V. Hayden states that this is "intended to be a type of a series of handbooks of different branches of natural history . . . . for the use of students all over the country." In the proper preface, which takes the form of a "Letter to the geologist-in-charge," Prof. Porter enumerates the various collections on which the work is based, as Parry's, Hall and Harbour's, Bell's, Hayden's, Brandegee's, Porter's, Coulter's, etc.; but omits Dr. Vasey, whose collection was among the largest of all, although no list was published. "The plan followed in the Synopsis is that of Mr. Watson in his excellent catalogue, vol. v of Clarence King's Report," giving characters of such orders, genera and species as are not included in the several floras of the

Cis-Mississippi region. After returning suitable thanks to the botanists who have aided the authors of this Synopsis, the writer adds: "References to the authorities consulted and used are to be found at the proper places in the body of the work." The Synopsis enumerates about eleven hundred (1104?) flowering plants, and about two hundred and eighteen cryptogams. Several new species of phænogams are proposed, as *Clematis Scottii, Astragalus Brandegei, Astr. scopulorum, Rosa Arkansana, Erigeron glandulosum, E. Coulteri* and *Senecio renifolius*, besides a couple of Mosses (by Mr. Lesquereux from Hall's collection), and a Fungus by Mr. Peck. Hall and Harbour's plants are generally referred to by numbers, and Parry's are sometimes; but a search through the pages of the Synopsis fails to discover any reference to Dr. Vasey's collection. Among plants collected by Vasey in the mountains of Colorado, and altogether omitted in this Synopsis are *Aster Canbyi* Vasey (No. 262); *Aplopappus lanceolatus, var. Vaseyi*, Parry (No. 273), and *Artemisia arbuscula* Nutt. (No. 308). The last two are described in Watson's report, to which it will presently appear that the authors constantly turned for assistance. The characters given to the genera and species not contained in Gray's and Chapman's floras will be found exceedingly useful to students and collectors. Very many of the plants of Colorado have hitherto been described only in various rare and expensive works, or in the transactions of learned societies, so that ordinary students had practically no means of identifying their collections. It is much to be regretted, however, that the writers of this Synopsis have by no means made the "references to authorities consulted and used" which it is said in Dr. Porter's letter that they have made. For example: the generic characters of *Brickellia, Townsendia, Machæranthera, Gutierrezia, Bigelovia, Aplopappus, Grindelia, Franseria, Heliomeris, Chænactis, Bahia, Tetradymia, Stephanomeria, Crepis, Macrorrhynchus, Orthocarpus, Monardella, Gilia, Collomia, Mirabilis, Abronia, Sarcobatus, Calochortus, Lloydia, Leucocrinum, Vaseya,* Eriocoma, Pleuraphis* and *Beckmannia* are taken with no alterations, save those incidental to inaccurate copying (e. g., *Bahia*), from Mr. Watson's report, and with no word of acknowledgment in any instance. Even when, as in the cases of *Cercocarpus, Cleome, Tellima, Gayophytum, Jamesia*, etc., the reference "Benth. and Hook." is given, the writers have copied Bentham and Hooker only from Mr. Watson's sometimes amended and always modified translations. To make this plainer yet: in *Cercocarpus* Bentham and Hooker say, "cotyledones lineari-elongatæ, radicula . . . . ." Watson says, "elongated cotyledons, and inferior radicle." The authors of the Synopsis copy Watson's words here, as elsewhere, and indeed there is no evidence that they have ever even seen the original Latin! The same disingenuous borrowing appears most copiously also in the specific

* *Vaseya comata* Thurber; Colorado, Vasey No. 634. This species surely might have been credited to Vasey.

characters. To quote any considerable portion of the instances were a tedious task; the following examples will suffice. *Thlaspi alpestre*, *Claytonia Chamissonis*, *Cercocarpus parvifolius* (an error in measurement is the only change), *Sedum rhodanthum*, *Brickellia Californica*, *Solidago Guiradonis* and its *variety*, *Solidago pumila*, *Franseria Hookeriana*, *Antennaria alpina*, etc. These are examples of exact copying. The instances where the copying is as real, though the wording is slightly varied, are much more numerous. One cannot but wish, for the honor of American Botany, that when Dr. Porter said that "the plan followed in the Synopsis is that of Mr. Watson," he had added, "and much of the descriptive matter is also taken from the same work."

DANIEL C. EATON.

NEW HAVEN, April 3d, 1874.

That the principal collaborator in Mr. Watson's volume should call attention to the scanty acknowledgement of the free use made of it is natural. That volume is a model in its way, and cost an amount of faithful labor (to say nothing of talent) which only those who do that kind of work can fully appreciate. The use made of it in the synopsis above noticed was natural and proper enough. That the lack of adequate reference to it in the brief preface was unintentional on Professor Porter's part, we were perfectly confident. The assurance received from him that it was a pure inadvertance is accompanied by the expression of his "sincere regret."

A. G.

15. *On the amount of pressure in the sap of Plants;* by Prof. W. S. CLARKE, of Amherst. (Eleventh Annual Report of the Massachusetts Agricultural College, January, 1874.)—It only remains to state in a few words the results obtained by the application of mercurial gauges to the sugar-maple, the black-birch and the grape-vine. Observations were made on one or more gauges several times daily, and occasionally every hour of the day and night, from the 1st of April to the 20th of July.

A gauge was attached to a sugar-maple, March 31st, which was three days after the maximum flow of sap for this species, so that further observations are required earlier in the season to complete the record and determine with certainty the maximum pressure which it exhibits in the spring. Of the record made, the following facts are specially interesting: first the mercury was subject to constant and singular oscillations, standing usually in the morning below zero, so that there was indicated a powerful suction into the tree, and rising rapidly with the sun, until the outward pressure was sufficient to sustain a column of water many feet in height. Thus at 7 A. M., April 21st, there was a suction into the tree sufficient to raise a column of water 25·90 feet. As soon as the morning sun began to shine on the tree, the mercury suddenly began to rise, so that at 9.15 A. M. the pressure outward was enough to sustain a column of water 18·47 feet high, a change represented by more than 44 feet of water. On the morning of April 22d the change was still greater, requiring for its representation 47·42 feet of water. These extraordinary fluctuations were not attended by any peculiar state of the weather, and happened twelve days before there were any indications of growth to be detected in the buds. These observations are believed to be quite new, and as yet inexplicable, but will receive further attention another spring.

The maximum pressure of the sap for the season was observed at 10 A. M., April 11th, and was equal to sustaining a column of water 31·73 feet high. This was an excellent sap-day, considering the lateness of the season. There was noticed a general correspondence between the flow of sap in other maples and the pressure on the gauge.

After April 29th the mercury remained constantly below zero, day and night. During the month of May there was a uniform suction equal to about eight feet of water, and the unaccountable feature of this fact is, that though apparently produced by exhalation from the expanding leaves, it remained the same, day and night, for several weeks. In June the suction gradually lessened, and finally disappeared, the mercury standing steadily at zero.

On the 20th of April two gauges were attached to a large black birch, one at the ground and the other thirty feet higher. The next morning at six o'clock the lower gauge indicated the astonishing pressure of 56·65 feet of water, and the upper one of 26·74 feet. The difference between the indications of the two gauges was thus 29·92 feet, while the actual distance between them was 30·20 feet, so that it corresponded almost exactly as if they were connected by a tube. In order to learn whether the same principle would prevail if the upper gauge was moved, it was raised twelve feet higher. The same correspondence continued through nearly all the observations of the season, notwithstanding the gauges were separated by 42·20 feet of close-grained birch-wood.

At 12.30 P. M., April 21st, a hole was bored into the tree on the side opposite to the lower gauge, and at the same level. Both gauges at once began to show diminished pressure, while sap issued freely from the orifice. In fifteen minutes, one pound of sap having escaped, it was found that both gauges had fallen equal to 19·27 feet of water. Upon closing the hole the gauges rose in ten minutes to their previous level, showing that the rootlets had re-absorbed in that brief period the sap which had escaped from the tree, notwithstanding the enormous pressure already existing.

A stopcock having been inserted into the hole opposite the lower gauge, it was found that the communication between it and the two gauges was almost instantaneous, which appears to prove that the tree was entirely filled with sap, exerting its pressure in all directions as freely as if standing in a cylindrical vessel more than sixty feet in height, as indicated by the lower gauge. The sap-pressure continued to increase until, on the 11th day of May, it represented a column of water 84·77 feet in height, which is believed to be the highest pressure of vegetable sap ever before recorded.

The buds of the birch now began to expand, the pressure of the sap to diminish, and the oscillations of the mercury to become more decided and regular than before. The upper gauge ceased to vary May 14th, remaining stationary at zero. The lower one declined slowly and varied greatly, but did not fall below zero until May 18th. On May 27th it also became stationary at zero. The suction manifested by the birch was very little, never exceeding nine feet of water, and continued only for a few days.

To determine, if possible, whether any other force than the vital action of the roots was necessary to produce the extraordinary phenomena described, a gauge was attached to the root of a black birch-tree, as follows: The tree stood in moist ground at the foot of the south slope of a ravine, in such a situation that the earth around it was shaded by the overhanging bank from the sun. A root was then followed from the trunk to the distance of ten feet, where it was carefully cut off one foot below the surface, and a piece removed from between the cut and the tree. The end of the root thus entirely detached from the tree, and lying in a horizontal position at the depth of one foot, in the cold, damp earth, unreached by the sunshine, and for the most part unaffected by the temperature of the atmosphere, measured about one inch in diameter. To this was carefully adjusted a mercurial gauge, April 26th. The pressure at once became evident, and rose constantly with very slight fluctuations, until, at noon on the 30th of April, it had attained the unequaled height of 85·80 feet of water. This wonderful result showed that the absorbing power of living birch rootlets, without the aid of any of the numerous helps imposed upon them by ingenious philosophers, such as exhalation, capillarity, oscillation, dilatation, contraction, etc., was quite sufficient to account for the most essential of the curious phenomena connected with the circulation of sap. Unfortunately, in an attempt to increase the capacity of the gauge, the bark of the root was injured, and this most interesting experiment terminated. There can be little doubt that future trials, carefully conducted with suitable apparatus, will achieve even more marvelous results.

The original experiment of applying a mercurial gauge to the grape-vine, first tried by Rev. Stephen Hales, of England, one hundred and fifty years ago, was repeated, May 9th, and a pressure of 49·52 feet of water obtained, May 24th. This is six and a half feet higher than was observed by Hales. The peculiar features of the pressure of the vine-sap are: its lateness in the season; its apparent independence of the weather; its uniform and moderate rise, day and night, to its maximum; its very gradual decline to zero without any marked oscillations, and its constant and almost unvarying suction of from 4·5 to 6·5 feet of water, manifested from June 20th to July 20th, when the observations ceased.

III. Miscellaneous Scientific Intelligence.

1. *The newly discovered Crater of Maui.* (From a letter of T. M. Alexander to the editor of the Hawaiian Gazette, dated Dec. 3, 1873.)—In surveying the district of Kahakuloa on West Maui, I recently discovered volcanic phenomena, quite remarkable for any of our islands except Hawaii. I ascended the mountain two miles west of Waihee, along the sharp crest of the western ridge of Makamaole Valley. At about half way to the summit, I found a crater the size and depth of that of Diamond Head, called Keahikano. The sides within and without were covered with the usual vegetation of our mountains, mantled over all the trunks and branches with thick elegant mosses, and interspersed with a few palm trees. The bottom of the crater and the greater part of the mountain above to the summit were overspread with a thick spongy moss, so saturated with moisture that every tread of the foot would press out a pint of water. Little pools of water ten or fifteen feet in breadth were also very numerous over this place and the upper portion of the mountain. Silver sword plants, strange ferns, violets, a species of daisy, and splendid lobelias, were abundant. But what especially attracted my attention was a pit in the center of the crater, extending fifty by one hundred feet, with its major axis nearly north and south, resembling the opening through which the violent eruption of lava poured forth twenty years ago on Mauna Loa. In the center of this was a rocky shaft, reaching to such a depth that pieces of wood thrown in were five seconds in falling, when they were heard to splash below. This was evidently the throat of an ancient volcano now choked with water.

Ascending southwest, out of this crater, I crossed over a broad plateau, well named from its abundance of water, Kalaniwai, on which were many more such pits. I estimated that there were over seventy on the whole mountain. Above this plateau I came to another crater, of which I wish especially to speak. This crater, called Eke, is of about the size and depth of Punchbowl crater, stretching from near the Waihee to the Honokahau Valley, forming the terminal point of valleys for seven or eight miles of the coast, and the reservoir, as I was told, of the greater part of the streams of the Waihee, Kahakuloa and Honokahau Valleys. In this crater, situated in all parts of it, were nearly a score of volcanic pits, not cones, but pits fifteen to fifty feet broad and ten to twenty feet deep, with shrubbery within concealing the chasms below. Passing around the northern brink, and near the Honokahau Valley, I was surprised to see a slender column of steam or smoke, rising from one of these pits. It was a cold, clear morning before sunrise, with a light south wind blowing, so that there was not a particle of cloud or fog upon the whole mountain to occasion such a phenomenon. Going near, I perceived that white fumes were indeed arising from a chasm through the shrubbery at the end of the pit. There were four natives with me, whom I called, and who were as much astonished at the sight as myself. A few rods further toward the Honokahau Valley, I found a pit with two such columns of steam or smoke arising, one from each end, and beyond others; and at last two on the Waihee side of the crater, nearly a fifth of a mile from the first fuming chasm. I counted in all six such columns of steam or smoke. I could not perceive any sulphurous odor to the fumes, nor much if any warmth to them. Very little lava was to be seen. A few basaltic columns appeared supporting the lower side of the crater; but the rock of the region was chiefly feldspathic, decomposing into a stiff white clay.

I was inclined to suppose that these pits were connected with subterranean chambers heated by volcanic action; and that the air arising from these warm depths on a cold morning, if not already pervaded with smoke, was at least changed into fumes of steam. Very likely at the warmth of midday this phenomenon would not be seen.

I am not aware that fumes like these have been seen arising out of craters on any of these islands excepting Hawaii. None has been seen in the evidently more recent crater of Haleakala.

No white men have, to my knowledge, hitherto visited this region. I have as yet been unable to find any natives who have ever ascended to it, or who have ever known of its phenomena. There being no canoe-timber here, they have no occasion to ascend high up on the mountain. It is quite startling to some people here to learn that a volcano close by, apparently dead for over one thousand years, is still breathing.

This whole region was evidently once the theater of very violent action. Other hills above and below are extinct craters; while at the sea near Honokahau are many bluffs of black volcanic sand, similar to those thrown up thirty years ago in Puna, where a lava stream poured into the sea. It is interesting to imagine the ancient scene, when lava torrents were pouring down the slope of this mountain into the ocean, and when these numerous volcanic throats were volleying fire and screaming in concert.

This region can be reached by the route by Makamakaole Valley, and also by ascending from Lahaina above Mount Retreat, then crossing the head of Honokahau, and thence descending the ridge between that valley and Waihee. But it is hardly safe to ascend so far up the mountain without preparation for erecting a shelter from rain and for spending a night, and excepting at times when light south winds have cleared away the fogs. * * * *

By examining the craters of this region one can easily perceive how the deep valleys of our mountains may have been formed. When the almost bottomless chasms had become watercourses, and had at length by their whole depth worn through adjoining sides of the mountain, valleys would have been thus begun, deep almost as the depth of the mountain. This process is now seen in the wasting away of these craters.

2. *The Polaris Voyage.*—The Report of this Expedition, now issuing from the Government printing office at Washington, furnishes the following data to the N. Y. Tribune of March 3d. Dr. Bessels submitted a memorandum of the most important discoveries of the expedition. The results of the expedition may be summed up briefly as follows:

(1.) The Polaris reached 82° 16′ N., a higher latitude than has been attained by any other ship.

Capt. Buddington's testimony is very definite as to the impracticability of pushing the vessel further north than the point which they reached.

(2.) The navigability of Kennedy Channel has been proved beyond a doubt:

(3.) Upwards of 700 miles of coast line have been discovered and surveyed:

(4.) The insularity of Greenland has been proved; and

(5.) Numerous observations have been made relating to astronomy, magnetism, force of gravity, ocean physics, meteorology, zoology, ethnology, botany, and geology, the records of which were kept in accordance with the instructions supplied by the National Academy, and some of the results of which we propose briefly to enumerate.

Great care was taken in determining a reliable meridian at Thank-God Harbor. Soon after entering winter quarters an observatory was erected on the shore, thirty-four feet above mean sea level, and the transit instrument stationed there. The longitude of this station was determined by the observation of three hundred lunar distances; a number of moon culminations; a great number of star transits; a number of star occultations; and a great number of altitudes of the sun on or near the prime vertical. Its latitude by the observation of a great number of circummeridian altitudes of the sun, and a number of altitudes of stars. All of these observations were lost, but a number of the results have been preserved which are sufficient to establish the position of this station. Besides the above-mentioned observations, twenty sets of pendulum experiments were made, which are saved, but the observations for time belonging to them are lost.

The magnetic observations obtained were more complete than any others ever before made in the Arctic regions. The instruments supplied were: One unifilar declinometer; one dip circle, with Lloyd's needles; one theodolite, and several prismatic compasses. The observations on variation of declination were registered at Göttingen time, and were continued for five months. Readings taken hourly. Beside that, three term days were observed every month, according to the Göttingen regulations, one of these term days corresponding with the day accepted by all the magnetic stations. Further, a number of observations were taken either with the theodolite or the prismatic compass. Whenever possible, the dip was observed, and several sets of observations on relative and absolute intensity and of the moment of inertia were obtained.

Unfortunately there was not much opportunity for taking soundings. About twelve were obtained along the coast of Grinnell Land, which prove that the hundred-fathom line follows the coast at a distance of about fifteen miles in Smith Sound. One of these soundings (ninety fathoms) proved highly interesting, containing an organism of lower type than the *Bathybius* discovered by the English dredging expedition. It was named *Protobathybius Robesonii.* A number of deep-sea temperatures were taken with corresponding observations on the density of the water. Following the coast of West Greenland, the limits of the Gulf Stream were ascertained. Specimens of water from different depths were preserved in bottles, but, unfortunately, lost.

After having entered winter quarters, meteorological observations, which up to this time had been made three-hourly, were made every hour, Washington time. The register contained observations on the temperature of the air, atmospheric pressure, psychrometrical observations, direction and force of wind, appearance of the sky, state of weather, and both solar and terrestrial radiation. Besides, all extraordinary meteorological phenomena were carefully noted.

Special attention was devoted to the aurora borealis, which occurred frequently, but rarely showed brilliant colors, never bright enough to produce a spectrum. Whenever necessary, one observer was stationed at the magnetometer and the other out of doors, the former observing the motions of the magnet, while the other was watching the changes in the phenomenon and taking sketches. Although an electroscope and electrometer were set up, and the electrical condition of the atmosphere frequently tested, in no instance could the least amount of electricity be detected. The amount of precipitation was measured as carefully as the violent gales would permit, by means of a rain gauge supplied with a funnel. In February, as soon as the sun reappeared, observations on solar radiation were commenced and continued throughout the entire summer.

The collections of natural history are nearly entirely lost. With the exception of two small cases containing animals, minerals, and one package of plants, nothing could be rescued. The character of the fauna is North American, as indicated by the occurrence of the lemming and the musk-ox. Nine species of mammals were found, four of which are seals. The birds are represented by twenty-one species. The number of species of insects is about fifteen, viz: one beetle, four butterflies, six diptera, one bumble-bee, and several ichneumons, parasites in caterpillars. Further, two species of spiders and several mites were found. The animals of lower grade are not yet ready for examination.

The flora is richer than could be expected, as not less than seventeen phanerogamic plants were collected, beside three mosses, three lichens, and five fresh water algæ.

Although the formation of the Upper Silurian limestone, which seems to constitute the whole west coast north of Humboldt

Glacier, is very uniform, some highly interesting and important observations have been made. It was found that the land is rising, as indicated, for instance, by the occurrence of marine animals in a fresh-water lake, more than thirty feet above the sea-level and far out of reach of the spring tides. Wherever the locality was favorable the land is covered by drift, sometimes containing very characteristic lithological specimens, the identification of which with rocks in South Greenland was a very easily accomplished task. For instance, garnets of unusually large size were found in latitude 81°30′, having marked mineralogical characteristics by which the identity with some garnets from Fiskenaes was established. Drawing a conclusion from such observations, it became evident that the main line of the drift, indicating the direction of its motion, runs from south to north.

3. *The Principles of Science: A Treatise on Logic and Scientific Method;* by W. Stanley Jevons, M.A., F.R.S., Fellow of University College, London; Professor of Logic and Political Economy in the Owens College, Manchester. 2 vols. 8vo., pp. xvi, 463; vii, 480. London (Macmillan & Co.), 1874.—The first book of this very interesting work, occupying somewhat less than half of the first volume, is an exposition of the principles of Logic in its more recent developments. Following Boole, De Morgan, and others, the author discards the cumbrous structure of the ancient logic, with its awkward machinery and terminology, and reduces the subject to the language of common sense. By the use of the principle of identity, the logical equivalent of the mathematical equality as expressed in equations, and by the application of his own fruitful and powerful method of substitution, the most varied kinds of propositions are made capable of expression by a symbolic notation of the utmost simplicity. The system is, at the same time, so comprehensive and flexible that it embraces with ease forms of argument which the narrow limits of the old logic could not be made to include. The new method renders the transformations of propositions, and their varied relations, so simple and clear, that the old modes of discriminating and naming them, with the whole apparatus for converting the syllogism, the barbarous names, and mnemonic lines, fall away as a lifeless superfluity. The whole science is thus greatly widened and extended, and while rendered more powerful as a guide in intellectual processes, is made practically useful. Other changes of similar effect and of great interest might be mentioned, but must be passed over for want of space.

The remaining books treat of the logical principles involved in the different processes of scientific investigation and reasoning. The topics of the successive chapters will make evident the scope of the work, and its general character. Book II. treats of Number, Variety, and Probability; Combinations and Permutations; Inductive Inference; Inductive or Inverse Application of the Theory of Probabilities. Book III, Exact Measurement of Phenomena; Units and Standards of Measurement; Analysis of Quantitative Phenomena; the Method of Means; the Law of Error. Book IV, Inductive Investigation; Observation; Experiment; Method of Variations; Theory of Approximation; Quantitative Induction; Use of Hypotheses; Empirical Knowledge, Explanation and Prediction; Accordance of Quantitative Theories and Experiments; Character of the Experimentalist. Book V, Generalization; Analogy; Exceptional Phenomena; Classification. Book VI, Reflections on the Results and Limits of Scientific Method.

The work is abundantly enriched with illustrations from actual incidents in the history of scientific discovery, and the bearing of the principles discussed upon practical problems, the suggestions of methods, the means of estimating or avoiding error, are treated in a very interesting and instructive way. It is eminently a book for the student of science, and the careful perusal of it cannot fail to further materially his progress toward clear thinking, accurate discrimination, and precision of statement. A. W. W.

4. *On Mr. Meek's note, p.* 373 *of this vol.*—While preparing the papers on the Crinoidea, published in this Journal in 1869 and 1870, Mr. Wachsmuth kindly lent me some of his beautiful specimens. In his letter, he directed my attention to the curious openings in the arms of *Actinocrinus*, and informed me that Mr. Meek intended to publish an account of them, in the Paleontology of Illinois. I therefore carefully avoided making any allusion to them in my papers. Specimens of *Caryocrinus* exhibited similar openings at the sides of the arms; and, although I wished to make some remarks about them, I refrained from doing so, lest I might indirectly anticipate Mr. Meek. (See this Journal, II, vol. 49, p. 52, where a diagram is given of the upper part of *Caryocrinus ornatus.*) I figured the ambulacral pores (those in which the grooves of the arms terminate), but not the lateral openings. I have never alluded to them in any of my papers. I believe the small ambulacral pores in *Caryocrinus* to be ovarian. Mr. Meek and others would call them oval orifices. But in what way the other orifices in *Actinocrinus* and *Caryocrinus* are to be explained, I have no idea. E. Billings.

5. *Corrections for the paper, on page* 193, *on the Connection between Isomorphism, Molecular Weight and Physiological Action;* by James Blake, M.D. (Letter from the author, dated San Francisco, March 4.)—The notes on the physiological action of the substances were intended to apply to the whole of the substances in each group, and not as they now read, as if different members of the same group produced different effects. In group 5 the substance experimented with was the double chloride of osmium and potassium and not the chloride of potassium, as printed. In describing the relative weights of the substances which prove poisonous (page 196), the comparison in line three should be between Li and Tl, and not Li and K, as printed, and in the next line the numbers should read ·12·5 : 1 and 10·4 : 1, instead of 125 and 104; and in line seven, Os instead of Pt.

APPENDIX.

Art. XLIX.—*Notice of New Tertiary Mammals.* III; by O. C. Marsh.

Among the remains described in the present paper are those of several *Edentates*, the first detected in this country in the Tertiary formation. The numerous extinct species of this order previously known, both from North and South America, are all from more recent deposits.

Morotherium gigas, gen. et sp. nov.

The present genus appears to be most nearly related to *Megalonyx* and *Mylodon.* From the former, as well as from *Scelidotherium*, it may readily be distinguished by the humerus, which has no supra-condylar foramen; while from the latter genus, it differs in the femur, which is without a depression for the round ligament. The more slender femur, and the concave ulnar articulation of the humerus separate it likewise from *Megatherium.* The skull of the present genus is not known.

In this species, the femur is stout, and in its general proportions resembles that of *Megalonyx Jeffersonii* Harlan. The head of the femur is hemispherical, but slightly expanded in an antero-posterior direction. The great trochanter is massive, and rugose, and is raised slightly above the neck. It is somewhat recurved, and encloses a deep pit, as in the elephant. The third trochanter is represented only by a rugosity, mainly on the lower half of the shaft. On the posterior surface, there is a prominent ridge extending from the great trochanter obliquely across the shaft toward the inner condyle. The trochlear surface for the patella is broad and shallow, and is separated by a deep groove from each of the condyles; the inner groove being about twice the width of the other. The humerus is expanded at its distal end. The olecranon cavity has little depth, and there is no perforation above the inner condyle. The latter has its articular face concave transversly, as in *Mylodon.* The outer and inner deltoid ridges unite below, terminating in a double tuberosity.

Measurements.

Length of femur,	450·mm·
Transverse diameter at proximal end,	217·
Antero posterior diameter of head of femur,	106·
Transverse diameter,	98·
Least transverse diameter of shaft,	130·
Least antero-posterior diameter,	55·
Width of trochlear surface,	82.
Vertical extent,	50·
Transverse diameter of outer condyle,	78·
Least transverse diameter of shaft of humerus,	93·
Antero-posterior diameter of ulnar condyle of humerus,	70·
Transverse diameter,	63·

The known remains of this species indicate an animal about two-thirds the size of *Megalonyx Jeffersonii* Harlan. The specimens here described are from Pliocene strata, in Central California.

Morotherium leptonyx, sp. nov.

A smaller species, apparently of the same genus, is indicated by some fragmentary remains, the most characteristic of which is an ungual phalanx of the third digit of the fore-foot. This resembles most nearly in form the corresponding bone in *Megalonyx Jeffersonii* Harlan, but differs from it in the much less developed ungual sheath, and in the presence of a large rounded tubercle on the lower side, instead of a flat basal plate. The articular facets are quite unequal, the inner being considerably larger and deeper than the outer. The ridge between them is obtuse. The ungual sheath has its greatest development on the inner side. There is a large vascular foramen on the outer side at the base of the tubercle, and on the opposite surface this is replaced by several smaller orifices. This phalanx, when entire, was about 90^{mm} in length. It is 42^{mm} in vertical diameter through the basal tubercle, and 24^{mm} wide across the articular facets. The specimen was found in the Pliocene beds of Idaho, and has been kindly loaned to me for examination by my friend, Prof. J. S. Newberry, of Columbia College.

Stylinodon mirus, gen. et sp. nov.

A new extinct mammal of great interest is represented by portions of both jaws with teeth, and a few other remains, which were obtained by the writer last autumn in the Eocene deposits of Wyoming. These specimens resemble in some respects the corresponding parts of the genus *Toxodon* Owen, from the Quaternary of South America; but may, perhaps, have some more affinities with the Edentates. The lower jaw preserved is massive and deep, and contained six molar teeth, all essentially alike, and inserted in deep sockets. They all grew from persistent pulps. In form, they are nearly cylindrical, with an approach to a quadrate outline in transverse section. The outer and inner faces are covered with a thin layer of enamel. A portion of a large incisor was found with this jaw, and evidently pertains to the same animal. This tooth was large, and somewhat curved. Its outer face was coated with enamel, marked with transverse lines of growth, and vertical striae.

Measurements.

Extent (approximate) of six lower molars,	75·mm·
Antero-posterior diameter of third lower molar,	11·
Transverse diameter,	12·3
Width of external layer of enamel,	9.
Thickness,	1·
Length of inserted portion of upper molar,	41·
Depth of pulp cavity,	20·
Width of band of enamel on incisor,	22·

The only remains of this species now known are from the upper Eocene of western Wyoming. They belong to a single individual, which was about as large as a Capybara.

Tillotherium latidens, sp. nov.

A second species of the peculiar genus *Tillotherium* is indicated by some remains from the same geological horizon in which the type species, *T. hyracoides* Marsh, was found.* The most characteristic of the new specimens is a last upper molar with its crown unworn, and in perfect preservation. This tooth has essentially the same crown-structure as the corresponding molar of the above species. It differs, however, in having a prominent buttress attached to the posterior side of the postero-external cusp, and a small elevated tubercle on the outer margin of its base. On the posterior side of the crown, the basal ridge thickens into a high crest, which unites with the single inner cone. The enamel of this tooth is coarsely rugose. The close resemblance of the true molars in *Tillotherium* to the premolars in more specialized forms is an interesting fact, and indicates for this genus a primitive type of dentition.

Measurements.

Antero-posterior diameter of last upper molar,	22·mm·
Antero-posterior diameter through outer lobes,	26·
Antero-posterior diameter through inner cone,	23·

* This Journal, v, p. 485, June, 1873.

Transverse diameter through center,	36·mm·
Transverse diameter through anterior lobe,	41·
Height of crown through antero-external cusp,	14·
Height through inner cone,	14·5

The type specimens of this species are from the upper Eocene of Wyoming. They indicate an animal about the size of a Tapir.

Elotherium bathrodon, sp. nov.

The largest species of this genus hitherto discovered in the West is represented by a few remains in the Yale College Museum from the Miocene of Dakota. Among these specimens is a perfect lower molar tooth, apparently the last, which belonged to an animal at least double the bulk of *Elotherium ingens* Leidy, from the same region. This molar differs essentially from the same tooth in the other known species of this genus, especially in having the anterior pair of tubercles much larger than the posterior pair, and elevated high above them. There is also a distinct basal ridge, which at the posterior end of the crown thickens upward into an obtuse heel. This ridge nearly disappears on the sides of the crown, but is well marked in front. The enamel is rugose.

Measurements.

Antero-posterior diameter of last lower molar,	47·5mm·
Transverse diameter through anterior cones,	34·
Transverse diameter through posterior cones,	28·
Height of crown in front,	28·
Length of fang in front,	55·
Height of crown at heel,	13·5

This species must have been nearly as large as a *Rhinoceros.* The only species of the genus that approached it in size is *Elotherium Leidyanum* Marsh, from the Miocene of New Jersey.

Yale College, New Haven, April 20, 1874.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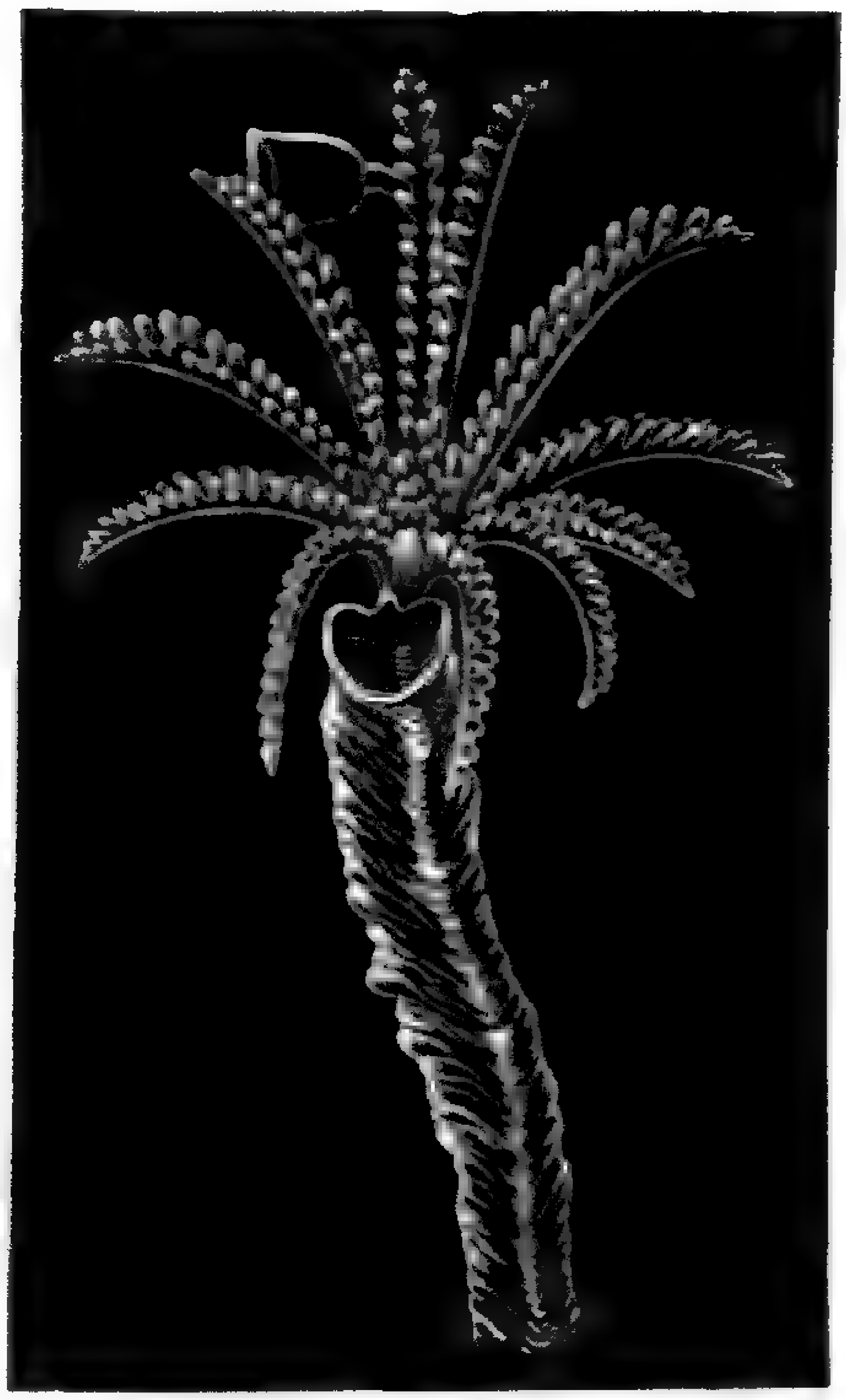

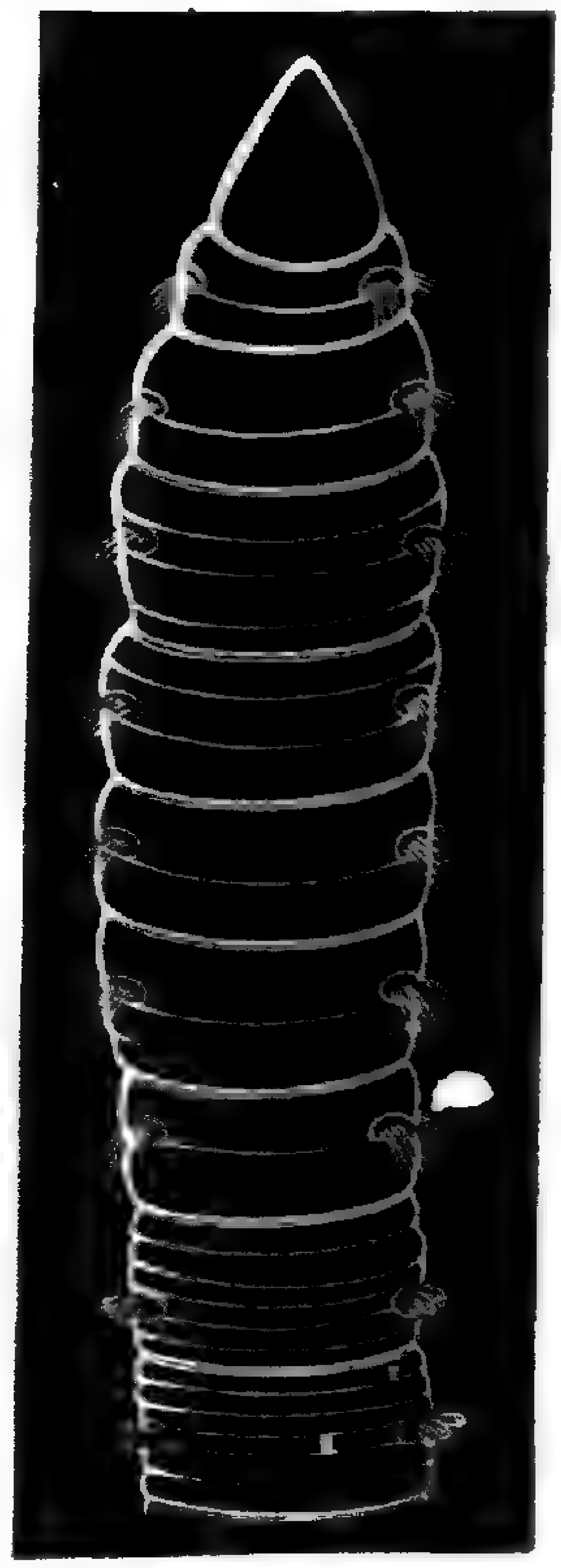

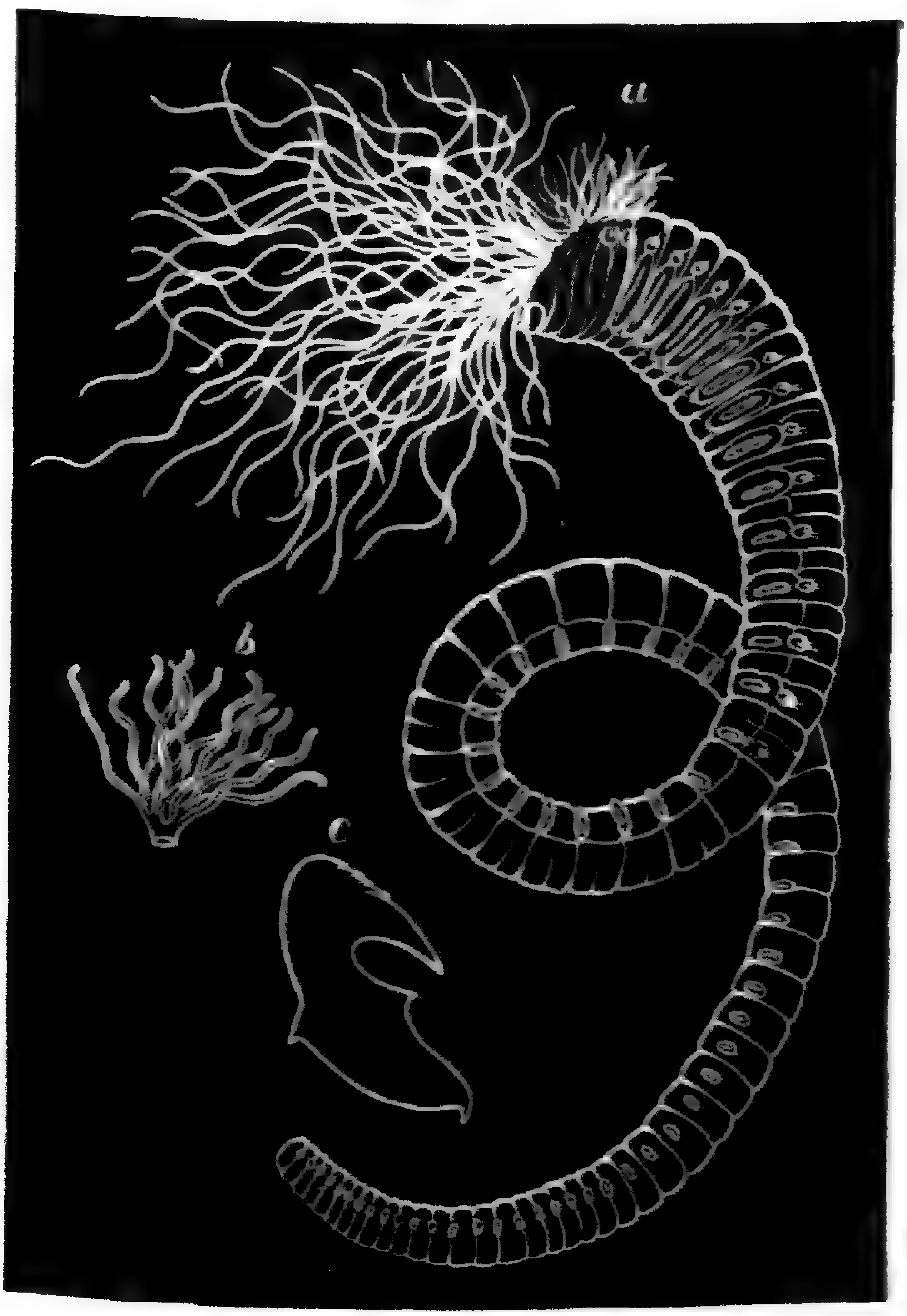
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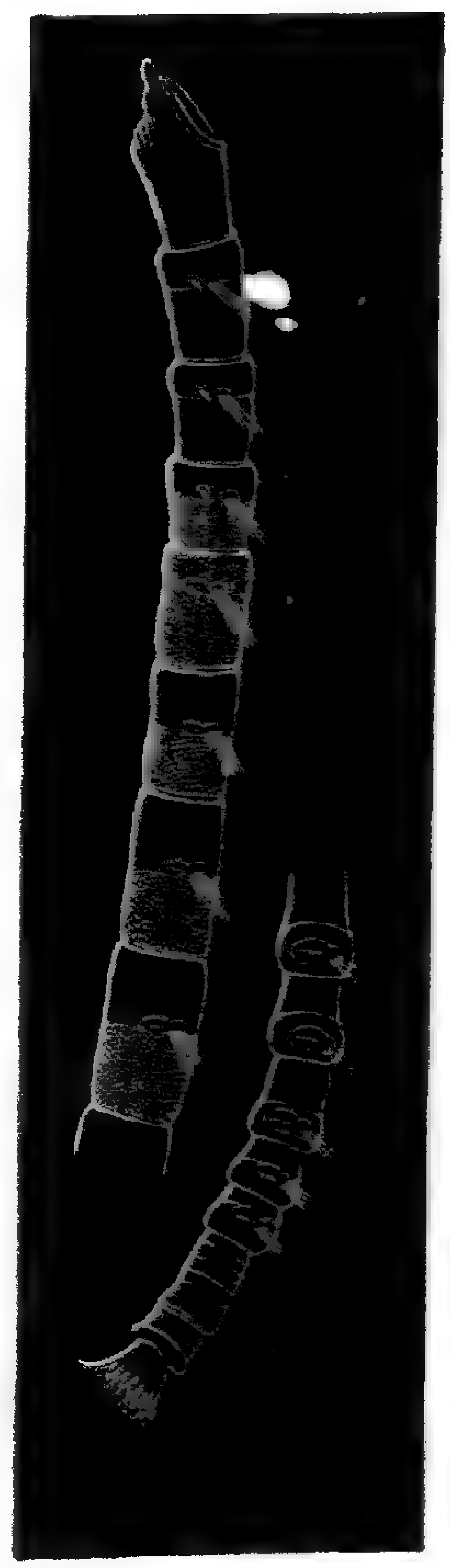


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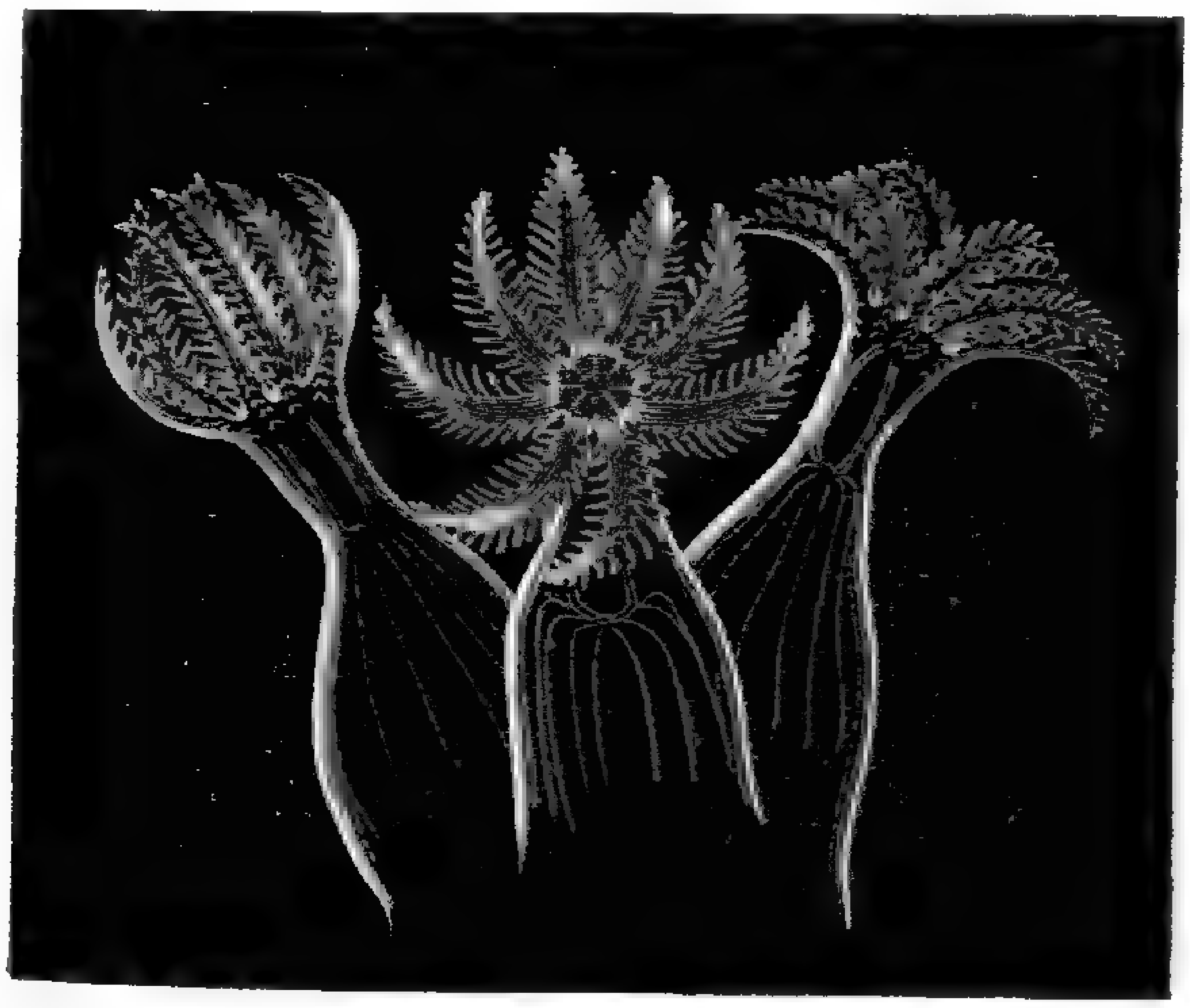

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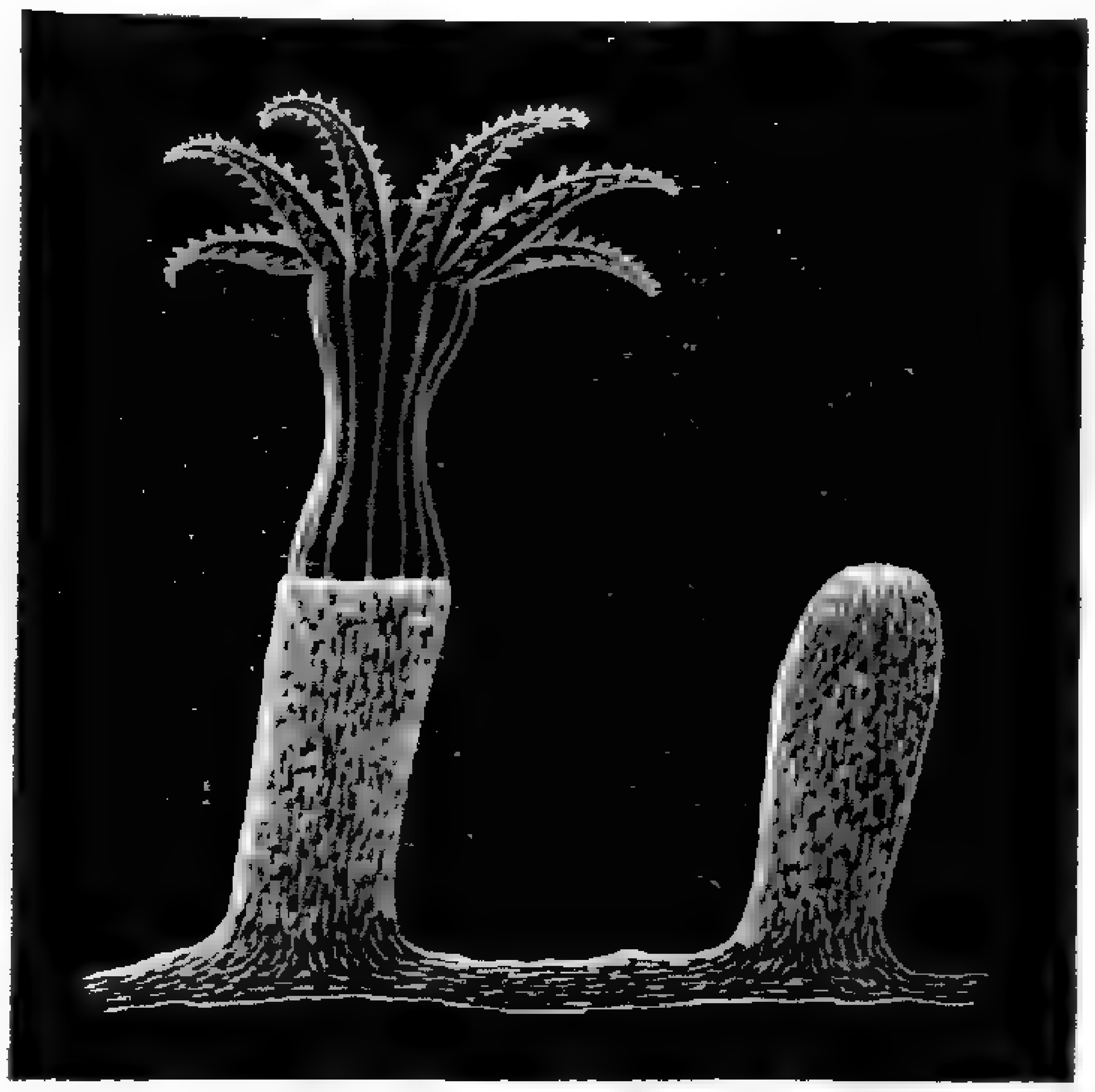

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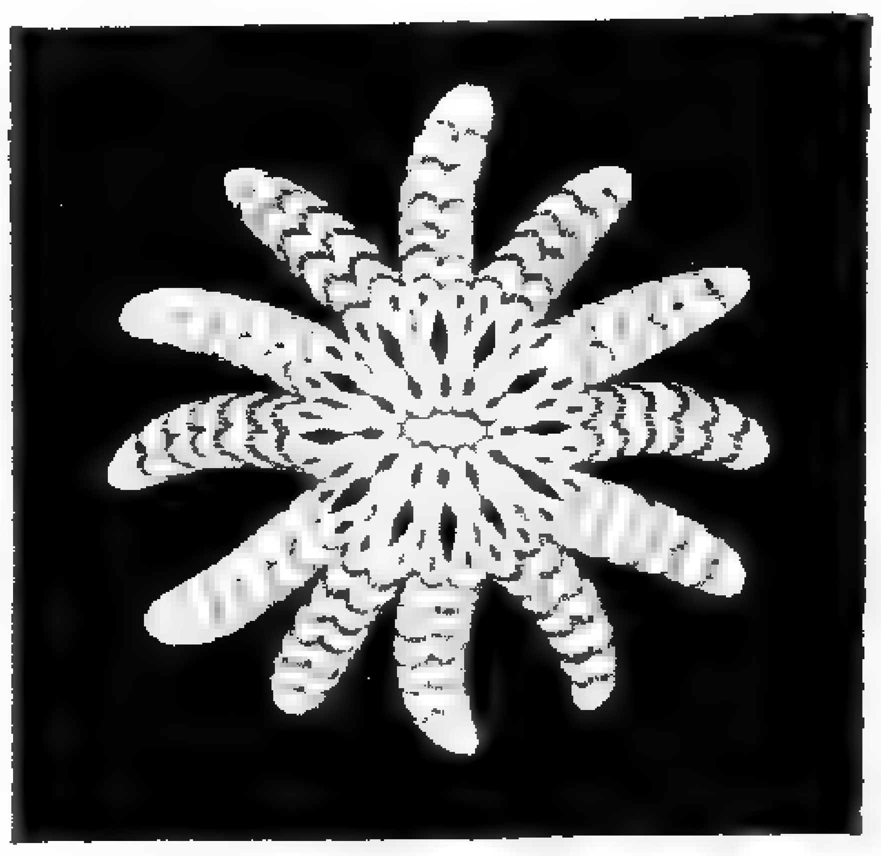

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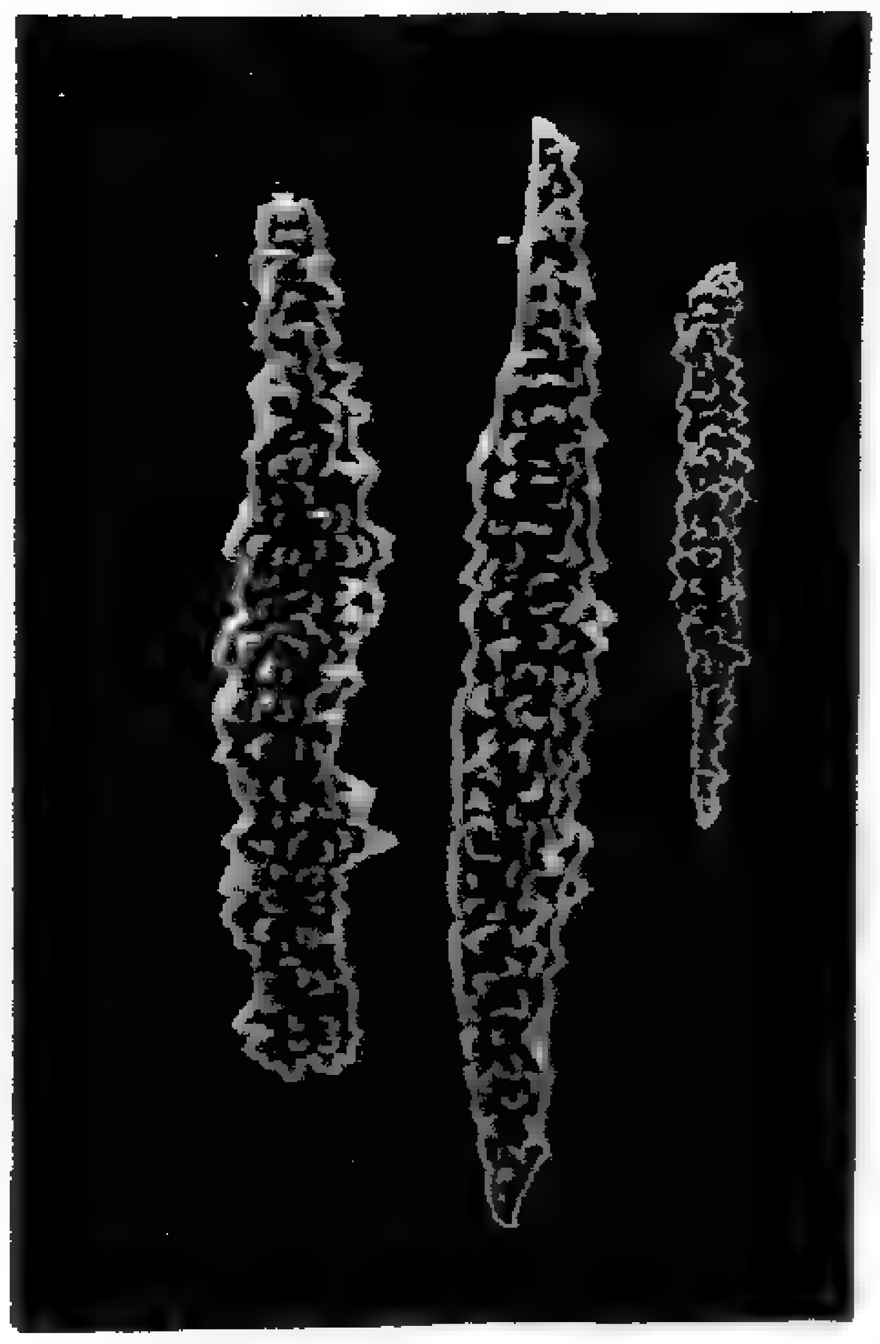

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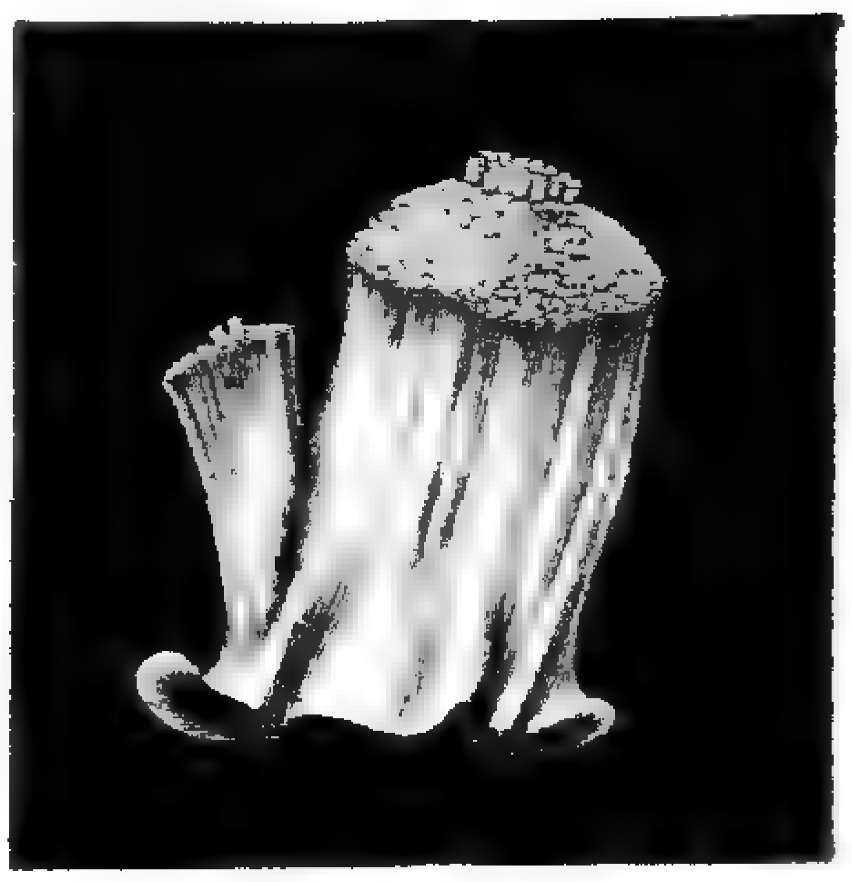

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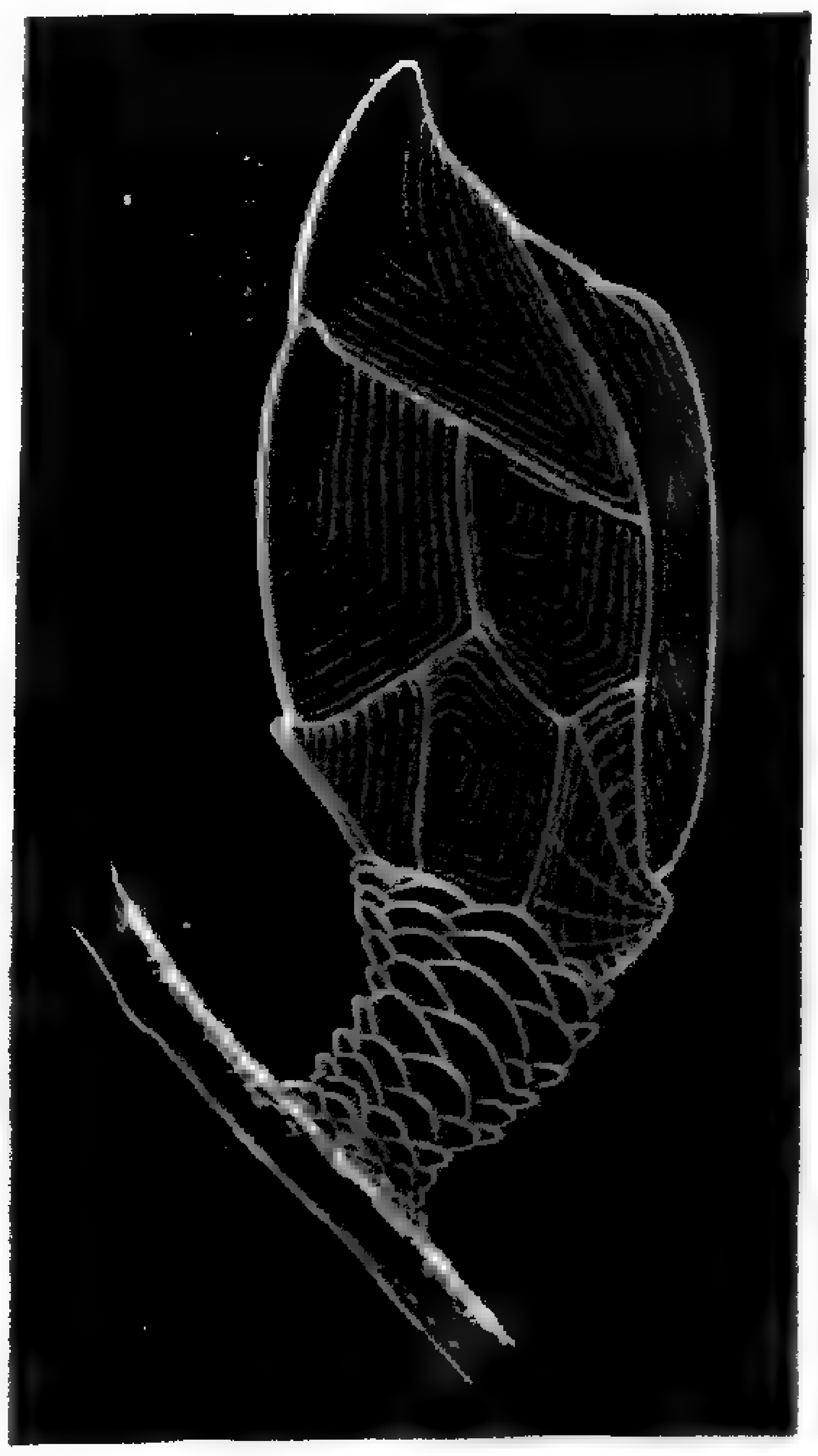

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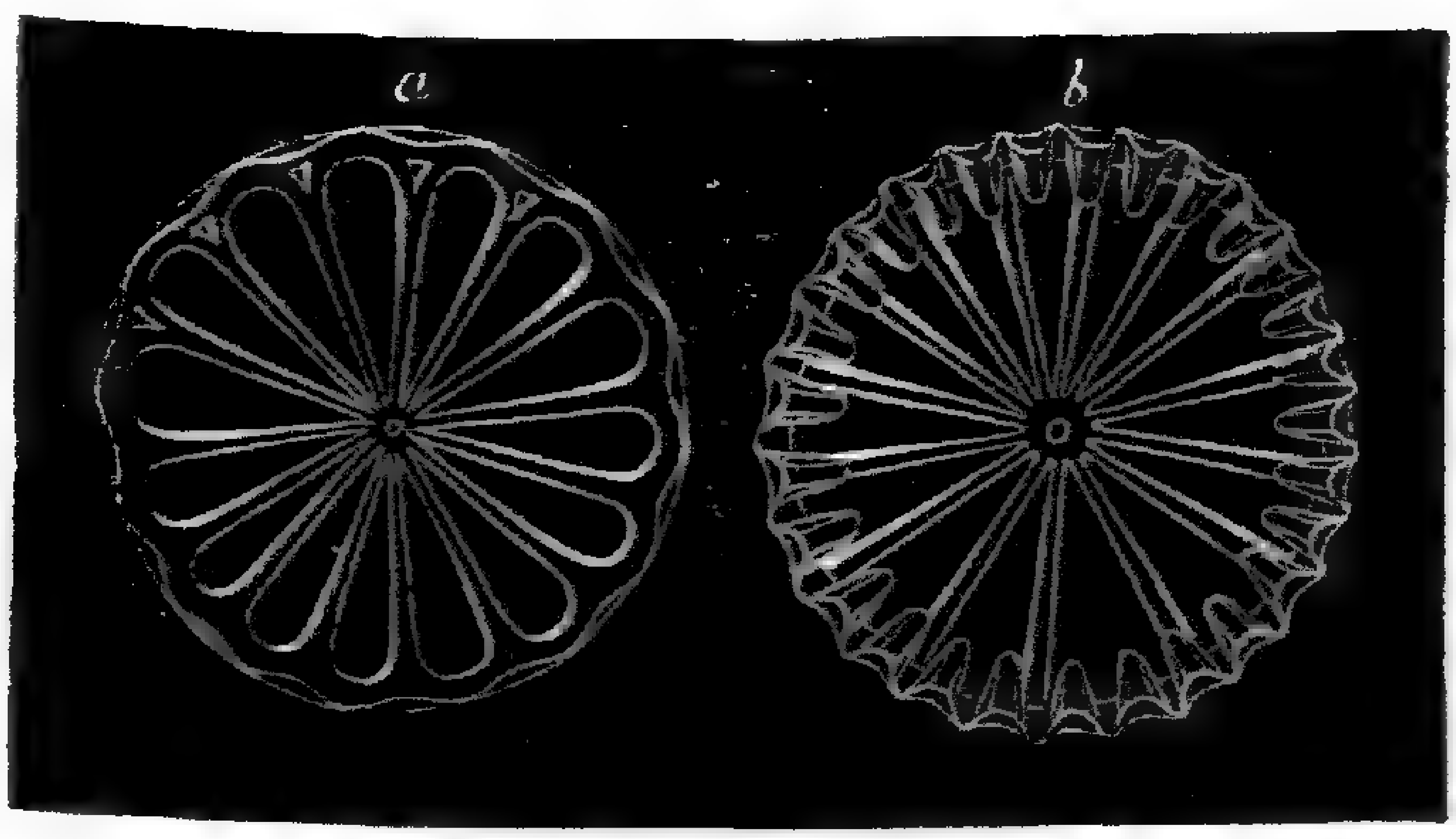

THE

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[THIRD SERIES.]

Art. L.—*On some points in Mallet's Theory of Vulcanicity;* by Eug. W. Hilgard, Univ. of Michigan.

[Presented to the National Academy of Sciences, April 24, 1874.]

The main points of Mallet's Theory of Vulcanicity have been before the world of science for some time, and have excited some lively discussions on both sides of the question; mainly in the English press. I think it is to be greatly regretted that the original memoir, very tardily published in the Transactions of the Royal Society, should be so difficult of access, that few of those interested are enabled to appreciate the caution and laborious conscientiousness which Mallet has brought to bear on his investigation and discussion of this most complex problem; and to what extent he has himself anticipated most of the objections raised. In calling attention to some apparent omissions in this respect, it may be useful to recall the state of the question as regards some of the more prominent points at issue.

The first and most sweeping attack upon the very basis of Mallet's theory comes from Sir Wm. Thomson, in a letter to Mr. Poulett Scrope (Nature, Feb. 1, 1872), in which he calls attention to, and re-affirms, the results of his investigation (supplementary to that of Hopkins) on the effect which a fluid nucleus and imperfect rigidity of the earth must exert upon precession and nutation; and which led him to the conclusion that, unless the rigidity of the globe as a whole were greater than that of steel, there must ensue a tidal deformation of the solid mass, which would sensibly change the amount of precession. He denies that Delaunay has shaken, in any important point, the conclusions of Hopkins or himself.

The subject has since been taken up by Gen. Barnard (Smiths. Contr., No. 240), who, while confirming the results of Thomson upon the premises assumed by that physicist, also shows that there are assumable and admissible conditions upon which a fluid nucleus with a moderately thick crust may exhibit the same constant, or periodically recurrent, amounts of precession and nutation, as a solid globe.

Mallet refers to Thomson's argument in favor of great rigidity as corroborative of the necessity for assuming a crust of great thickness, such as would render it inadmissible to assume a direct connection between volcanoes and the liquid nucleus. But it is difficult to see how the "preternatural rigidity," made a postulate by Thomson, could in any manner be compatible with the requirements of Mallet's theory. For the latter represents the earth's crust as a congeries of fragments, sustained partly by the contracting liquid nucleus, partly by each other on the principle of the arch; therefore necessarily often locally in a state of unstable equilibrium, and liable to be disturbed by slight outside forces. That the tendency to tidal deformation contributes toward producing such disturbances has been rendered probable by Perrey's discussions, and by the repeated coincidences of violent earthquakes with tidal extremes, lately observed.

Thomson's assumption, that the postulated rigidity might result from compression, would scarcely seem admissible save in a case of *absolute* homogeneity and equilibrium—if then. It is certainly incompatible with the demonstration made by Prof. Belli of Pavia (as quoted by Mallet), to the effect that rigid bodies are weakened by the simultaneous application of orthogonal pressures; that no known materials could sustain, under any circumstances, a strain several hundred times greater than that which would crush it if laterally free to yield. That such strains exist in the contracting crust, and that upward deformation must result, if such contraction takes place at all—as the annual loss of heat by the earth compels us to assume is the case.

Whether we view the question of rigidity by the light of our direct knowledge of the first twenty-five miles of crust, and of the profound commotions it experiences from time to time; or by that of the demonstrated increase of temperature as we descend, rendering it extremely probable that at a comparatively slight depth the rigidity of all materials must be seriously impaired by a high temperature, despite of pressure; or whether we even consider alone the secular loss of heat by radiation, which must result in a contraction affecting unequally the heterogeneous *couches* of which, on any hypothesis, the solid portion of the earth must be composed; it will be difficult to persuade geologists of the actual existence of the "preternatural rigidity," until every reasonable hypothesis that can dispense with this assumption shall have been exhausted.

Among the objections raised by geologists, the first and apparently gravest was that of Forbes (Nature, Feb. 6, 1872), who argues the untenableness of Mallet's theory on the ground of the asserted general identity of composition of volcanic ejecta. In fact, from Mallet's point of view it would seem, that lavas might have the composition of any fusible rock whatsoever, in whose strata the crushing might happen to occur; and hence that, if taking place within the sedimentary strata, there ought to be a very great diversity between the ejecta of different vents.

In his rejoinder, Mallet calls attention to the very serious differences of composition between the extremes of trachytic and basaltic lavas, and to the generally admitted fact that volcanoes are located along axes of upheaval, where the hypogene rocks, and therefore those of the crust proper, approach the surface; hence that crushing along these lines of weakness would be by no means likely to produce a greater diversity of lavas than we actually observe. Furthermore, that the "local lake" theory is liable to the same objection, unless the lakes are supposed to be located within the (uniform) crust itself.

He might, it seems to me, have added that the maximum of twenty-five miles of sedimentary rocks is not anywhere (on the continental areas at least) actually superimposed, vertically, upon the crust; and hence that it is not unreasonable to assume that a pressure sufficiently great to produce fusion may never occur within the limits of the sedimentary strata, albeit other manifestations of subterraneous thermal action may not be wanting. It is true that, on the whole, Mallet's memoir leaves upon the reader's mind the impression that he seeks the source of volcanic action at depths sufficiently shallow to justify in a measure the objection raised by Forbes: although he expressly declares that with our present data, the determination of the points at which the maximum of crushing effects occurs is impossible.

Similar considerations apply to the objection raised by F. W. Hutton (Nature, Nov. 27, 1873), that "faults show no heating effects, even where considerable crushing has taken place." The pressure under which the faulting occurred may have been inadequate, in the cases coming under our observation; but above all, *time* is a most essential element in this connection. No matter how great the dislocation or crushing, no great increase of *temperature* can occur if it takes place *slowly*, however great may be the *quantity* of work performed, or of heat produced. And very many, if not the majority of extensive faults actually occurring, show evidence of having been formed without cataclysmal disturbance.

Among the other points raised by Hutton (*loc. cit.*) there are several which are at once disposed of by a perusal of the original memoir. There are others of some weight. That "lines of least resistance once chosen must remain," is doubtless true in a very wide sense; and in that sense this is scarcely at variance with observed facts, since the lines of weakness along the borders of continents are still those which exhibit volcanic activity (and earthquake phenomena) most frequently. But, in the folding and upheaving of strata by tangential thrust, the question of equilibrium must often of necessity be very delicately balanced; depending as it does upon the vertical pressure of the masses, their nature, dislocation, subsequent consolidation, igneous effusions from fissures, etc. Lines of weakness as to *rigidity* may thus easily acquire sufficient *static* resistance to cause a subsequent yielding to take place at some distance from the original axis; as is exemplified in the formation of successive parallel ranges. What is true with regard to the formation of folds, is equally so as concerns the settling down of the crust-fragments in consequence of interior contraction. Each fragment as a whole may remain as such, being only as it were abraded at its circumference. But it is only necessary to have observed the gradual yielding of detrital rock masses under pressure, to understand why the cataclysmal yielding which manifests itself in earthquakes should so frequently change its locality of occurrence; why for long periods a region may be completely exempt from these movements, in consequence either of an unresisted and therefore gradual descent of the crust fragments underlying it, or of an arch-like arrangement, whose sudden breaking down will result in a catastrophe, succeeded perhaps by a long period of quiescence.

Thus, Mallet's theory accounts equally well for the sporadic and apparently lawless occurrence of seismic phenomena, and for the probable correlation between the frequency and violence of earthquakes, and tidal extremes. Unlike the theory of a thin crust, which would lead us to expect almost diurnal earthquakes corresponding to oceanic tides, according to Mallet's view, there should be a near coincidence in time and space of two independent factors (viz: of a condition of very unstable equilibrium of some crust fragment, with a tidal extreme), in order to produce a maximum of disturbance. It cannot be expected that such coincidence should be of frequent occurrence, or that the casual connection should manifest itself in a greater predominance than that claimed by Perrey for the times of spring and neap tides. Mallet does not, however, allude to this point; whether from a distrust of Perrey's data and method, or theoretical scruples on the score of "rigidity."

The objection that, according to Mallet's theory, earthquakes ought always to be followed by eruptions, could obviously apply only during the period of fissure eruptions from the liquid interior; it being conceded that the volcanic eruptions of to-day are due to contact of water with the molten rock, and that steam, not static pressure, is the *vis-a-tergo.* It is, of course, very probable that the access of water to the volcanic focus* is generally caused, or facilitated, by such crust movements as would at the same time result in the production of more heat, and perhaps of fused rock; such movements being indicated by the (mostly slight) earthquakes that so frequently precede a period of volcanic activity. Hutton's objection, that according to Mallet's view each eruption ought to be preceded by a sensible subsidence, is therefore groundless.

One point, however, must strike every reader of the original memoir, viz: the pre-eminence given by Mallet to the *crushing of solid rock* as the means of producing heat and fusion. One would naturally look to the results of his experiments on this subject for the proof of the efficiency of this agency. But we find that the maximum of *temperature* resulting from the crushing to powder† of the hardest rock, is something over 217° Fahr. This, then, represents the maximum increment of temperature that can be rendered efficient toward the fusing of rocks by the crushing process, under the most favorable circumstances, viz: upon the supposition that it takes place instantaneously, or under such circumstances that the heat cannot be conducted away; and farther, that the resistance of the rock has not been materially diminished by the downward increase of hypogeal temperature. At the most moderate depths at which volcanic phenomena can be supposed to originate, the last mentioned factor must exert a very considerable influence, reducing materially the available heat-increment. Hence the numerical results of Mallet's laborious experiments on rock-crushing, however interesting and useful as affording a definite measure of the thermal effects producible by this means, yet fail to carry conviction as to the efficacy of this particular *modus operandi* in reducing large masses of solid rock to fusion —unless essentially supplemented by *friction;* not so much of

* Hutton (*loc. cit.*) avers that "to cause a volcano the heat must go to the water —the water cannot go to the heat;" but omits any explanation of this singular axiom.

† Mallet does not go into the consideration of the physical nature of this "powder," and of the thermal and other differences likely to result from its production under pressures enormously greater than those employed by him.

rock walls against each other, but more probably by the heat produced within more or less comminuted *detrital*, or *igneo-plastic* masses, by violent pressure and deformation.

It may be doubtful what would be the physical and thermal effect of enormously great pressures upon rock powder such as was produced in Mallet's experiments; but it would seem that if *made* to yield, the frictional effect must produce very high temperatures. *A fortiori*, solid detrital masses of variously sized fragments intermingled (such as, rather than powder, would be likely to result from steady pressure), yielding rapidly under great pressures, might, under the *combined influence of friction and rock crushing*, well be supposed to reach the temperature of fusion, which a simple crushing of a solid mass by pressure would have failed to produce. Mallet mentions the probable influence of friction, and of the squeezing of igneo-plastic masses; but does not attach to these agencies such importance as they seem to me to deserve.

Of the complex thermal effects of the movements of detrital masses under great pressure, Mallet's figures of course offer no measure whatsoever; nor is this, or even the thermal co-efficients resulting from his rock-crushing experiments, at all necessary to the establishment of the postulates of his theory.

Taking for granted the correctness of Hirn's theorem, "that the heat evolved in the crushing of rigid bodies is the equivalent of the work performed," Mallet's experiments on the contraction of fused rock in cooling, and his estimates of the amount of volcanic energy manifested on the globe, coupled with that of the earth's annual loss of heat, completed the proof of the *quantitative* adequacy of the cause invoked by him. And when it is understood that the earth's present loss of heat during sixteen and a half years is the mechanical equivalent of all the volcanic work performed since the period of fissure eruptions, the burden of proof of the *qualitative* inefficiency of the several modes of action that may come into play, would seem to be effectually thrown upon the opponents of the theory.

Among these modes of action, the fusion of masses already existing in a pasty, or generally more or less igneo-plastic condition, by squeezing or forcible displacement, seems to me to deserve especial attention. At the depth at which volcanic phenomena must be supposed to originate, this condition must be closely approached; especially in the early times of the volcanic period—that of the "Maare" of the Eifel, and other similar cases representing the transition phase between the régime of fissure eruptions and that of volcanoes proper. In this period of a "greatly stiffened and thickened crust," even slight flexures, whether synclinal or anticlinal, would occasion great displacements and movements in the half-stiffened upper layers of the "viscous *couche;*" and if these experienced local refusion, the fused matter may well be presumed to have often been disposed of by eruption through fissures or volcanic vents, rather than by overcoming, downward, the inertia of the viscous *couches.* This mode of action seems to me likely not only to afford a more copious, but also a more constant or lasting source of supply, than the supposed crushing of solid rock, and appears especially applicable to the case of large fissure eruptions.

Among the greatest services rendered by Mallet's (or, in this connection, Wurtz') theory, is the unstrained explanation of many of the phenomena of metamorphism, that were quite unintelligible so long as the heat required for the observed changes was supposed to be derived from below, and perhaps by transmission through strata which themselves had experienced little or no change of condition. The principle that the heat evolved in the flexure or forcible compression of strata is, *cæteris paribus*, proportional to the resistance offered by them to the external force, throws a flood of light upon numerous apparently contradictory phenomena, which have long been quoted as incompatible with the doctrine of metamorphism as held in this country, and have stood in the way of its general acceptance by geologists, particularly on the continent of Europe. In its application to the formation of synclinoria especially, the principle works most instructively and satisfactorily. It can scarcely be doubted that in the first folding of the vertex of a geosynclinal, weakened below by fusing away and heating of the crust and lowest strata, the movements were comparatively localized and rapid, and therefore capable of producing high temperatures, and their results such as we now usually find them along the main axes of elevation of synclinoria. But as the resistance along this axis increased by emergence and solidification, the points of yielding, i. e., the folds, would be *multiplied*, while the absolute amount of motion transformable into heat would be *diminished* in each. Hence the decrease, *in general*, of metamorphic effects, as we recede from the main axis. And yet it is perfectly easy to conceive of large local exceptions to the general rule (such as we actually observe), on the basis of greater resistance in perhaps a localized stratum of a lateral fold, yet so situated that it could not successfully resist the influence of an advantage of leverage causing a rapid deformation. It is even predicable that under such circumstances, sudden breaks and crushings must occasionally have occurred, giving rise to fusion of rocks and limited fissure eruptions; or, at the least, to pasty rock intrusions, as suggested by Dana, for granitic and analogous veins, that show no evidences of the co-operation of very high temperature in the act of formation.

LeConte's view, that the first mashing of a geosynclinal would produce *less* heat than later plications,* in which (presumably) a greater resistance would have to be overcome, seems hardly to be compatible with facts as generally observed, away from the Pacific coast eruptions; and his argument is the less cogent, as the temperature produced is a function, not only of the resistance of the rocks, but also of the *degree* and *rapidity* of the motions, both of which have been on the decrease in late geological periods, in accordance with the diminishing rate of contraction of the earth and the increased resistance of the crust to flexure.

While Mallet's theory accounts satisfactorily for earthquake phenomena and volcanic activity as manifested since the cessation of fissure eruptions: and also for the gradual or sudden *depression* of both large and small areas, even subsequent to that time; it makes no provision for their *elevation*, and therefore leaves unexplained the numerous *oscillations* of level of which we find the record, down to our own time. In assuming the movements as taking place exclusively within the solid shell, he (unnecessarily as it seems to me) leaves a point open to objection.

While admitting that slow secular oscillations, or those minor changes of level constantly occurring in volcanic areas, may even now in many cases be reasonably attributed to changes of temperature occurring within the solid rocks themselves, and within their limits of elasticity: it is impossible to assign this as an adequate cause of those extensive oscillations which have characterized the Quaternary period, and are recorded, e. g., by the raised beaches of the North Atlantic coasts and inlets; and by the drift pebbles even now found four hundred and fifty feet below the level of the Gulf of Mexico, while the emerged formations record a complementary elevation to at least a similar extent during the Terrace epoch. This record of an oscillation of near a thousand feet on the Gulf shore since the glacial drift epoch, implies *at least* a corresponding one over the greater portion of the area drained by the Mississippi, unless that river flowed backward at one time.† Doubtless

* On the great Lava-flood of the West. This Journ., March, 1874, p. 179.

† It is a curious fact that in the various hypotheses regarding the oscillations of the continental interior during the Drift epoch, the facts observed on the Gulf shore have over and again been quietly ignored; although the Gulf is unequivocally the natural reference level most directly related to that interior, not only at the present time, but as the direction of the Drift currents and the trend of the formations show, ever since the time of the Cretaceous emergence. Nevertheless, the reference level has been sought beyond the Allegheny upheavals, or beyond the fixed Azoic area upon which the movement appears, in a measure, to have pivoted, and where, as Dana has shown, it was materially diminished in extent. Assuredly, no hypothesis which disregards the changes of level registered at the continental outlet, has any *raison d'être!*

these oscillations, like the glaciation of which they probably were coöperative causes, were of continental extent, as was the (more or less contemporary) emergence of the Siberian plain; and as such, they must be presumed to have been true movements of the earth's crust, although lying quite within the volcanic period proper. It is but reasonable to suppose that the sinking of the great Pacific area was then, and may still be, of a similar nature.

If Mallet's theory, as well as the geological facts with which it deals, is incompatible with Hopkins' and Thomson's postulate of extreme rigidity; if, as it appears to me, the events of very recent geological epochs, in connection with the very slow rate of cooling since that time, render it unlikely that the crust can even now be considered as rigid in a geological sense; if finally, as Gen. Barnard affirms, the astronomical objection to a comparatively pliant crust and liquid nucleus is not absolute, but may be obviated by admissible assumptions regarding the mode of distribution of the solid and liquid matter constituting the globe: we are led to the reasonable assumption that, while the thickness and rigidity of the crust is evidently too great to admit of farther folding, or fissure eruptions, and (probably) to admit of connecting ordinary volcanic phenomena directly with the (virtually or actually) liquid interior, yet we need not assume it to be so great as to render the crust incapable of yielding somewhat, *on a large scale*, to static upward pressure. Such pressure may be either the resultant of tangential stress, such as might slightly deform an arch without fracture or folding; or even the direct result of a corresponding subsidence elsewhere.

The latter effect would of course be incompatible with a shrinking away of the fluid interior from the crust, as required by Mallet's theory, if it were necessary to assume that the interior crust-surface is substantially "smooth," i. e, free from important downward projections or upward sinuosities. But so far from this, the cooling influence that has so long acted on the oceanic areas, contrasted with those enormous outwellings of igneous rock that have occurred even in late Tertiary, or Post-Tertiary times, together with other considerations, necessitate the assumption that such inequalities do exist to a notable extent. Hence the overlapping alluded to by Mallet, of the period of fissure eruptions and of that of volcanic activity proper, which appear to have coëxisted, in *different* portions of the globe, from early Tertiary to early Quaternary times. For even Mallet himself considers the outpourings of igneous rocks on the Pacific coast as "wholly inconsistent with existing volcanic forces," and few geologists will agree with LeConte * in

* This Journal, March, 1874, p. 179.

ascribing precisely these most extensive fissure eruptions in the world to the "ineffectual fires" of the volcanic period, arising alone from transformed motion.

Indeed, it is not easy to understand the precise mechanism of the great fissure eruptions as a consequence of nucleal contraction, without the aid of some static head of pressure that may exist more or less locally, in consequence of inequalities in the crust (whether of form, thickness or density), and thus act as a *vis-a-tergo.*

At first blush, the "squeezing out of sub-mountain liquid matter," assumed by LeConte as the consequence of the folding and fissuring of strata by tangential thrust, appears natural enough. Yet it seems hardly possible that the same force which makes and *elevates* mountain folds (being the *result of interior shrinkage*) should at the same time serve to *compress the interior liquid;* unless either such folding occurs beneath the general level of the liquid; or the latter is locally confined; or the movement is so (comparatively) brusque or cataclysmal, that viscosity would prevent the lateral or downward escape of the liquid rock. In the case of the Pacific eruptions, the evidence of steady static outflow, and regular upbuilding, is especially cogent; and as LeConte remarks, it has been slow work —as, indeed, is usually or universally the case with mountain building.*

The assumption of locally limited fire seas with a solid globe, as made by Dana† in conformity with Hopkins's views, would remove the difficulty, if the crust could be assumed as contracting, on the whole, independently of the portions over fire seas. But when we come to discuss the application in detail of this intrinsically improbable hypothesis, we find the required extent and localities of these fire seas to be such, that we can hardly imagine them to be effectually separated from each other; in other words, we approach very near to a condition of general under-crust fluidity, up to late geological periods.‡ It then becomes a question of minor importance, whether there is a central nucleus solidified by pressure, or whether all within the crust is actually liquid.

* When LeConte says (loc. cit., p. 179) that the outsqueezing of the liquid has been caused by "enormous horizontal pressure, determined by the interior contraction of the *whole* earth;" and then (p. 180) that "whether by uplifting or upbuilding, the actual increase of height would be precisely the same, being determined by the amount of lateral crushing," he seems to think of crust-contraction upon a nucleus *too large* for it, rather than of Mallet's "freely descending" crust. Or, if he considers the fused rock as the result of motion transformed, it is difficult to see on what ground a simple "*uplifting*" could be considered the precise mechanical equivalent of an *upbuilding* by eruption of liquid rock. In either case the *lifting* done would be the same; but what of the enormous *heat of fusion?*

† On some of the Results of the Earth's Contraction, this Jour., Aug., 1873, p. 105.

‡ Ibid., July, 1873, p. 7 and ff.

The inherent improbability of the depression of a geosynclinal trough to a level so low as to allow the liquid rock to *rise into it*, as it were, is too great to render its discussion necessary.

Indeed, it seems almost impossible to imagine a mechanism explaining satisfactorily fissure eruptions such as those of the Pacific coast, on the basis of a slowly contracting *solid* crust with a rapidly contracting *liquid* layer or nucleus beneath. A more satisfactory explanation seems possible, if in accordance with Mallet's suggestion, and the intrinsic probabilities of the case, we assume the existence of a thickly viscid, igneo-plastic under crust layer. Such a layer, while barely, or very slowly, obeying the laws of liquid equilibrium, would be capable of being liquified by a slight increase of temperature, such as might be produced by squeezing or kneading. Portions of such plastic matter would occasionally become involved in the anticlinal folds of synclinoria, and thus supply the material for limited fissure eruptions, in that case literally "squeezed out." But the inverse ratio pointed out by Dana as existing between folding and fissure eruptions, points to the rarity of such events.

At any rate, they could not explain the outwellings of the Pacific border, which continued long after close plications had ceased to be made; in fact, as it would seem, up to the end of the period of elevation of the main Sierra Nevada.

It is but fair to assume that near lines of weakness indicated by plications or fissure eruptions, the isogeotherms *have been* during the elevation of mountain chains (and probably still *are* where such lines are marked by volcanic vents) considerably above their general level. In an anticlinal upheaval, they would probably conform to the progress of the sublevatory movement, in a ratio more or less directly proportional to the rapidity of the upward movement; and would gradually descend during periods of repose. This would happen independently of any heat generated by transformation of motion.

In a polygenetic chain like the Sierra Nevada, after the collapse and folding of the geosynclinal and the subsequent stiffening of the backbone (so to speak), any further elevation of the *main ridge* becomes a *quasi* anticlinal movement, accompanied necessarily by the compression and "squeezing" of the heated rocks embraced within the arch. The heating being greatest, *cæteris paribus*, where the resistance and motion is a maximum, more heat would be generated by the compression of the upper, half-stiffened portion of the viscous or igneo-plastic layer, than in the lower ones; and the liquid matter so formed would constitute a head of pressure, from which fissure eruptions might derive their material; whether directly, or by pressure communicated to more distant points of rupture and fusion by lateral stress.

If then, as LeConte's data seem to show, the final and most considerable anticlinal elevation of the great interior range took place during the same period that witnessed the great fisssure eruptions of the Coast and Cascade ranges, it may not be unreasonable to suppose these events to have not only been contemporaneous, but to have borne to each other something of the relation of cause and effect: and that each of the numerous superimposed strata of igneous rock in the latter region may represent, not only the direct effect *in loco* of more or less paroxysmal thrusts, but also the reflex action of the simultaneously progressing anticlinals in the high Sierras.

ART. LI.—*On the Age of the Lignitic formations of the Rocky Mountains;* by L. LESQUEREUX.

PROF. J. S. Newberry has published, in a former number of this Journal (*On the Lignites and Plant-Beds of Western America*), some remarks bearing directly on my views of the Eocene age of the Lower Lignitic formation. As the data from which my conclusions have been derived are therein incorrectly represented, I find it necessary to state the case as it is, merely considering, in this answer, the advantage of science, in order that subsequent researches in our American vegetable paleontology may not be encumbered by misunderstandings.

I will successively answer the propositions of Dr. Newberry, which are presented as follows:

1st. *The flora of the Colorado Lignite-beds has almost nothing in common with that of the European Eocene. Its botanical aspect is certainly entirely different, and, in my judgment, not a single species and scarcely any genera are found in both.*"* In confirmation of this statement and to prove the assertion *that "in a botanical point of view he is quite safe in the statement that the Eocene flora has not yet been recognized in this country*, he adds: *that the Eocene flora, as exhibited in the Island of Sheppey, at Mt. Bolca*, etc.,† *has a distinctly tropical and Indo-Australian character.*

This last statement, literally translated from Prof. Heer (Flor. Tert. Helvet., iii, p. 314), forces me to consider the matter with somewhat more detail than I should have done if I had been limited to the examination of facts concerning our American paleontology only. And I am the more disposed to meet the objection, because I have already exchanged some remarks on this subject with Prof. Heer.

The flora of Sheppey cannot be taken into account for a comparison with the fossil plants of our Lignitic, mostly repre-

* Loc cit., p. 400. † Loc cit., p. 402.

sented by leaves, for the good reason that this flora of Sheppey or of the London clays has furnished to the researches and to the examination of Bowerbank a large number of fruits—nuts and seeds, of various and uncertain affinity—and nothing more. They are literally heaped in the clay, without any trace of leaves or of other vegetable organs. Fruits of this kind have not been found elsewhere in the Tertiary strata of Europe, except a few mentioned, and not yet described, from Mt. Bolca, by Massalongo, and two *Nipadites* (the genus which more than any other represents an Indo-Australian type), in the Miocene of the Bouches du Rhone, France. These Sheppey fruits, as Heer remarks, are not characteristic of the formation, and do not even furnish any evidence on the climate of the locality where they are found, as they may have been floated from great distances and are analogous to existing deposits of this kind at the mouth of the Ganges. The flora of the Island of Wight, at Alum Bay, recognized as Eocene, has furnished leaves of *Azalia*, *Daphnogene*, *Ficus*, *Zizyphus*, *Cæsalpinia*, which, according to Heer, have such a marked tropical and subtropical character that the fruits of Sheppey may have been derived from the plants of this region. These leaves, to quote the same authority, are very similar to species of Mt. Bolca; *three species* are identified as the same, and, too, a number of them are Miocene, as *Quercus Lonchitis* Ung., *Laurus primigenia* Ung., *Myrica* (*Dryandra*) *acutiloba* Brgt., *Cassia phaseolites* Ung., and other species of *Laurus*, together with species of *Quercus* and *Juglans*. As no description has as yet been given by Massalongo of the species of the Eocene of Mount Bolca, from which Heer derived his statement in regard to its character, we have no data for comparison. In his table of the families of plants which Massalongo has observed in the Mt. Bolca flora, Heer mentions as more numerously represented 48 species of *Algæ*, 5 *Podocarpi*, 7 *Palms*, 5 *Proteaceæ*, 10 *Ericaceæ*, 10 *Sterculiæ*, 15 *Leguminosæ*, etc. Neither in this, nor in the comparison of species made above, can I find a more marked Indian and Australian type than is indicated by what I consider as our Eocene flora. But, further, the genera named from Alum Bay, *Daphnogene*, *Ficus*, *Laurus*, *Quercus*, *Myrica*, are all represented in our Lower Lignitic flora; and of species positively identical with those of Alum Bay, we have *Laurus primigenia* and *Quercus furcinervis*, this last from Black Butte, also sent by Prof. Jos. LeConte in numerous and very fine specimens from Tertiary strata overlaid by lava beds, in Oregon, together with leaves of *Podocarpus*, also a European Eocene genus. And as very closely allied to, if not identical with Alum Bay and Mt. Bolca species,* we have a *Daphnogene* from Golden, and a

*** Neither the species of Alumbay nor those of Mt. Bolca have been described; a close comparison is therefore not possible.**

Myrica from Black Butte; these, with a number of species of Palm and of Fucoids. So much for the assertion that *not one of the species, not even a genus of the Eocene of Alum Bay and Mt. Bolca, are represented in our Eocene flora.*

But this question has to be considered from another point of view. Prof. Heer has included nearly the whole Tertiary flora of Europe in a single division of the Tertiary, the Miocene, referring to it the Sotska, the Mt. Promina, the Bornstædt, the Mt Vegrone floras, etc., which he places in the Tongrian or Lower Miocene. Except perhaps for the flora of Sotska, the European paleontologists have not admitted this division. Neither Ettinghausen, nor Saporta, nor Schimper have taken it into account in their works. Even Prof. Heer, in his introduction to the flora of Bornstædt, is undecided as to its reference to the Eocene or the Miocene. Now it is especially to the Upper Eocene flora of Europe, as known from Mt. Promina, Bornstædt, the lower gypsum beds of Aix, the old Travertines of Sezane, these last positively referred to the Eocene by Saporta, that our Lower Lignitic flora is related; not only by most of its genera but by positively identified species. With the Promina flora we have as identical *Sphenopteris eocenica*, *Goniopteris polypodioides*, *Flabellaria latania* and apparently *Paliurus zizyphoides;* and also from Golden this year two species of *Nelumbium*, one of which is closely allied to *N. Buchii* of the same Promina flora; with that of Bornstædt, a *Pteris* and a *Diplazium*, intimately related to *Pteris Parschlugiana* and *Diplazium Mülleri; Quercus angustiloba* A Br., which Mr. Meek and myself found, in fine specimens, in the hard white sandstone overlying the lowest coal bed of Golden, at a short distance above the Cretaceous clay-beds, with *Flabellaria Zinkeni*, *Diospyros brachysepala* and *Juglans Ungeri.**

To this positive evidence by identity of species we have the general Eocene facies of Europe represented in the Lower Lignitic flora by the great abundance of *Sabal* leaves and palm fruits in all the localities where fossil plants have been found, from Placiére Mountain, New Mexico, to Rock Spring, Wyoming. At some places, as at Black Butte, Golden, Colorado Spring and the Raton, the palms seem to have composed one-half of the whole vegetation. At Golden, Sabal leaves have been found of enormous size, the petioles of some of them measuring three inches across and two inches on each of the sides. In the coal also are found large carbonized trunks of palms, whose texture is perfectly preserved; and all around in the hills the ground is strewn with fragments of silicified wood of the same kind of plants. In Europe, all the

* This last species is not positively ascertained, the specimens of the past year's collection being now under examination.

Sabals as yet described, eight species, belong to the Eocene, three only ascending to the Miocene. With this, the lower Lignitic flora has a predominance of fucoids, already remarked, and of subtropical and tropical types, not seen in any other stage of our Tertiary, and still less in the Cretaceous floras; large leaves of *Ficus* of the palmate-nerved section; of *Cinnamomum*, *Dombeyopsis*, etc.; the large *Platanus Haydenii* and *Pl. Raynoldsii*, both abundant at Golden; also large leaves of *Magnolia*, *Myrica* (formerly *Dyandroides*), distinct species of *Quercus*, a *Viburnum* whose leaves are as large as those of a *Platanus*; southern types of *Sapindus*, *Rhus*, *Ilex*, and *Juglans*, with entire leaves.

Prof. Heer remarks on another character of the Eocene flora of Mt. Bolca, a negative one, which is perfectly recognizable in our Lower Lignitic flora. It is the great scarcity or nearly total absence of some families and genera of plants: the *Conifers*, *Salix*, *Populus*, *Alnus*, *Ulmus*, *Betula*, *Planera*, *Corylus*, *Acer*, *Tilia*, *Carya*, etc. All these forms of leaves with serrate borders are mostly absent from our Eocene as well as from our Cretaceous floras. They appear at a higher stage of the Tertiary, first at Evanston, more abundant still at Carbon, and still more in the Upper Miocene flora of the Green River group.

The second objection of Dr. Newberry is: *That the tuberculate fucoid Halimenites, considered by me as a diagnostic of the Eocene, is in New Mexico the most characteristic plant of the Cretaceous sandstone.*

But this so-called Cretaceous sandstone with *Halimenites* is, most probably, the heavy sandstone which underlies or intersects the Lignitic, wherever it has been observed, in Colorado, New Mexico (as far south as Trinidad, at least) and Wyoming. It is therefore the question now at stake, to know whether this formation is Eocene or Cretaceous: and it cannot be decided by a mere affirmation. We cannot say anything about the flora of those so-called Cretaceous strata of New Mexico, observed by Dr. Newberry, before his fossil plants are published, or before any thing pointing out their exact geological relation is ascertained. Even the proximity to what he calls the gypsiferous marls proves nothing; for the Dakota group, which appears to be a shore formation, does not extend far to the west, and to my belief does not reach New Mexico. If it is so, the Lignitic there should be in close proximity to the Permian. But this is mere surmise, and I will not go out of my defensive position. It is for Dr. Newberry to furnish sufficient evidence on the geological age of the Lignitic strata which he has observed in New Mexico, and when he has done it as positively as I have for the Lignitic of Colorado, I shall certainly be prepared to accept his decision.

To return to the second objection expressed above, I refuse to accept as my own the assertion, *that the tuberculate Halimenites is a diagnostic of the Eocene.* I have merely remarked that Prof. Meek and other paleontologists have found it in all the strata like those of Coalville and of Bear River, where no other kind of fossil plants has yet been discovered, and which therefore have not furnished to vegetable paleontology any other evidence of their relation to the Eocene. As it is found in abundance, and everywhere in connection with the Lower Lignitic sandstone, I had to consider this fossil as a kind of leading species of this formation. But I positively remarked (p. 345 of Dr. Hayden's Report) upon the great quantity of fucoidal remains in the Lignitic sandstone of the Rocky Mountains, as in the Eocene of Europe, comparing the distribution of this class of plants in both formations. It is not therefore this *Halimenites* only which is a *diagnostic of the Eocene sandstone*, but the prodigious quantity of the fucoidal remains of numerous species. And this character, when I saw it so distinctly marked in the Raton Mountains, forcibly recalled to me the essential facies of the Mount Bolca and of the Flysch Eocene flora of Europe.

In the same way Dr. Newberry has misapplied what I said of the great abundance of Sabal leaves, as indicating the Eocene age of the Lignitic. Contradictory to this assertion, he says, *that Sabal and Palms are common enough in the Miocene.* Who doubts it? We have Sabal leaves in the Pliocene of California; we have Sabals living at our time and in our climate; why not in the Miocene? I considered the presence of Sabal in all the strata of the Lower Lignitic as a proof that *they are not of Cretaceous age.* No Sabal and scarcely any trace of palms have as yet been recognized in the Cretaceous of any country.* This cannot be negatived by asserting that they are common in the Miocene. I have remarked already that all the fossil species of Sabal described by European authors have been found in the Eocene.

The third objection of Dr. Newberry is *that Prof. Meek, Marsh, Cope and Stevenson, guided by molluscous and vertebrate remains found in the Colorado Lignite deposits, consider them Upper Cretaceous.*

Though these geologists have perhaps considered the lignites of Colorado as Cretaceous, I do not know that they have found, in support of their opinion, any paleontological evidence. Prof. Meek, according to his own statement, has not found any Cre-

* One *Flabellaria, F. longirachis* is described by Unger from a Cretaceous formation of Muthsmannsdorf in Austria, and one, *F. chamæropifolia* Göpp., from the Quadersandstein of Silesia. As remarked by Schimper, they belong to a peculiar type of palm.

taceous shells in the Lignitic of Colorado. Those of Golden come from the clay underlying the fucoidal sandstone. Why did not Dr. Newberry quote Hayden's opinions? No geologist has seen so much of the Lignitic, or has studied it so carefully as he has. Everywhere, in connection with the Lignitic formation, he has seen this sandstone, which he calls either *beds of passage*, or *of transition*, or *positively Eocene*. He has even found in Colorado one specimen of *Inoceramus* at its base. I have discussed the question of the so-called Cretaceous evidence by Mollusks in Hayden's Report (1872, p. 341), and will not repeat here what the critic could have answered by pointing to positive facts, if he had had any in contradiction of my assertions. But, in order to meet any farther discussion on this subject. I will take the case as it is clearly stated by Dr. LeConte, in his notes on the Geology of the Rio Grande.

He makes the following objections to my opinion on the Tertiary age of the Lignitic. I quote only those which directly bear on the question.

1st. *That the lignite beds west of the Rio Grande were found by Dr. Newberry in supposed Jurassic strata, and in the super-adjacent lower Cretaceous sandstones.*

2d. *That the lignite beds of the Rio Grande Valley are in such close proximity to the gypsiferous marl series as to require their reference to our Western Early Cretaceous, the Dakota group.*

3d. *That the beds of the Raton Mountains are undoubtedly Cretaceous, since both Mr. Owen and himself have obtained Inocerami in the sandstone containing coal.*

5th. *That M. Berthoud, as quoted by Hayden, found, in* 1862, *a bed of coal almost identical with the Golden City bed, with bluffs one and a half miles north, containing belemnites, etc.*

6th. *That Gen. Pierce obtained on each side of a coal-bed near Platte Cañon, ammonites, baculites, etc.*

On the first and second paragraphs, I can but repeat my former statement: that we know as yet nothing of the lignite beds of the Rio Grande and southern New Mexico, and have to wait for evidence from their fossil flora to certify their age. Dr. LeConte, however, states, on page 40 of his notes, a fact which seems to me contradictory to what he is endeavoring to prove. It is: *that from the proximity of the marl series, the absence of characteristic shells of the Middle and Upper Cretaceous, and the known existence (by Dr. Newberry's report) of Lower Cretaceous lignites west of Rio Grande, he infers that the anthracite beds (the Placière coal), belongs to that period, and that all the beds of which he has information along the valley are of the same age.*

I admit this last statement, that these beds are all of the same age. And as among the fossil plants found in connection with that Placière anthracite are Sabal leaves, sent to me by Dr.

LeConte,* I consider it as Eocene. And if, as I remarked above, the Dakota group does not extend to New Mexico, this explains the absence of the characteristic shells of the Middle and Upper Cretaceous, and the position of Tertiary lignite in proximity to the marl series.

On the third paragraph of Dr. LeConte, I have nothing to remark but this: that the shells reported from Dr. Owen's and Prof. Cox's exploration were found, as positively recorded in the note and the section of Prof. Cox,† at the base of the black shales (Cretaceous, No 4 of Hayden), which everywhere at the Raton Mountains, and from Trinidad to the Spanish Peak, underlies the Eocene sandstone which supports the Lignitic.

The discovery of Cretaceous shells half a mile north of a bed of coal, by my friend Capt. Berthoud, does not indicate that the strata-bearing shells overlie the coal. At Golden, the distance between the clay-bearing Cretaceous shells and the Lignitic sandstone and coal leaning against it is not more than a few rods. The Lignitic, however, overlies the Cretaceous. And, for the assertion of Gen. Pierce concerning a bed of coal on the Platte, with Cretaceous fossils on both sides, as nobody, not even Dr. LeConte, under the guidance of Gen. Pierce, has found this coal, it has to be erased from the page of reliable documents. All along the base of the mountains, especially from Platte Cañon to Coal Creek, the Tertiary and Cretaceous strata are much disturbed, often folded and crushed vertically against each other, and their relative position is very difficult to ascertain.‡

What is left then of the repeated assertion that fossil shells and bones of Cretaceous age have been found in the Lignitic basin of Colorado? A single, badly-preserved specimen of *Inoceramus*, found at the Raton Mountains, where the same locality has been visited by a number of geologists and explorers, and where none other has been discovered. I do not say this to throw the slighest doubt on the reality of the discovery, for I well know that a number of Cretaceous animal remains are found in Wyoming over beds of lignite. But I

* Dr. Hayden found at the same locality, *Populus balsamoides*, *Ficus tiliæfolia*, *Cinnamomum Mississippiense*, *Magnolia*, etc., all Eocene plants.

† Prof. E. P. Cox, in letter, April 6th, 1874.

‡ Since writing this, a most valuable and detailed letter, received from Capt. Berthoud, settles this question, as follows: "1st. That if Mr. Stevenson observed Inoceramus, Baculites, etc., in superposition to the lignites, it was clearly a case of local inversion; i. e., that, as shown in our lignitic basin, it has been so tilted up that with the coal seams near it, it was thrown over the perpendicular. 2d. That as remarked to Prof. LeConte, I found in the locality named a coal bed whose dip could not be ascertained, as it was badly cut by the drainage of a small gully. In bluffs north or northwest, I found several Baculites that seemed to come from a clay bed in the bluffs; but whether the coal was superposed to the clay or the clay to the coal, I could not say." All the remarks in this letter and sections of the localities are positive evidence of the Tertiary age of the Colorado Lignitic. More of it will be quoted in my report.

remark on this, in order to meet and to answer another unjust rebuke of Dr. Newberry, who, after repeating his assertions of the discovery of Cretaceous animal fossils over the Colorado lignite deposits, says:—"*That I point to my 250 species of fossil plants, claiming that they far outweigh the testimony of the animal remains.*" And adds: "*In fact, however, these fossil plants have very little bearing on the question.*"

The above is also, to say the least, a colored representation of my statements. To answer the objection that at Black Butte, Coalville, Bear River and other localties in Wyoming, the Lignitic beds and sandstone-bearing plants have been recognized underlying strata with fossil Cretaceous animals, I had to examine, if, from the nature of its compound and from its vegetable remains, the Lignitic formation should of necessity be considered as a whole, or, if it could be separated in two members, one representing the Upper Cretaceous, the other Lower Tertiary. For this examination, of course, the essential documents to be considered in view of my special researches are the fossil plants. From the large number of Fucoids in the Lignitic sandstone, from the identity of species of these marine plants found by Mr. Meek in connection with Lignitic strata as far down as the arenaceous beds bearing Cretaceous animal remains; from the prodigious preponderance of Palms, recognized also in the same circumstances from New Mexico to Wyoming, etc., I forcibly admitted the unity of the Lignitic formation, in its whole, and therefore limited the discussion to this point: the Cretaceous or the Tertiary age of the formation. In order to strengthen my position in regard to the value of the conclusions afforded by vegetable remains, I compared the Lignitic formations to those of the Carboniferous epoch, remarking that, having positively a preponderance of land-plants over marine animals, or a land character, they should be considered as land formations, and that therefore the evidence given by the fossil plants should outweigh in importance that of some Cretaceous animal remains, whose presence could be considered as of a casual occurrence, etc. That in every geological formation, especially in every land formation, like that of the Carboniferous, fossil animal types were more or less in non-coincidence with the vegetable forms, in regard to the data furnished by them respecting the age of the formations. For, in the Carboniferous, we find Devonian mollusks far above the Millstone grit, and also Permian shells far below the base of the Permian, even as far down as the middle of the Carboniferous measures. These, however, are nevertheless admitted now by everybody to constitute a single homogeneous formation, which is not modified in its essential points — the coal beds and their plants—by the introduction of some foreign species. Contrary to the assertion that the fossil plants have little bearing on the question, it is clear, therefore, that it is from the evidence furnished by vegetable paleontology that the question has to be decided.

I have been, however, careful to consider the data furnished by animal paleontology in regard to the age of the strata. I have quoted Prof. Meek's passage of a letter where his opinion is recorded rather in favor than in contradiction of mine. I could have remarked too that he has even found at Black Butte and identified fresh water shells of the species of the Upper Missouri Eocene: that, too, certain species of shells found in the same bed with Prof. Cope's Dinosaurus are hardly distinguishable from modern species, etc.

Prof. Cope's conclusions, in his Review of the Vertebrata of the Cretaceous, &c., which is just published, do not in the least interfere with my own. They prove only the non-coincidence of animal and vegetable types in some formations; and all my remarks on the presence of coal-beds formed from land-plants and of vegetable remains as furnishing the logical characters of the formation, have their full value. This discordance is less embarrassing in a case like this than it might be in the case recorded by Pictet, who derived from a detailed study of the animal fossils contained in the Cretaceous strata of St. Croix, Switzerland, and a comparison with contemporaneous repositories, an argument in favor of the idea propounded by Barrande: that two successive faunas must necessarily have existed together for some time. He concludes this remark by showing that paleontological faunas distinguished throughout by marked characters are not ordinarily susceptible of any rigorous limitation. That may be. But if Tertiary and Cretaceous faunas are regarded as contemporaneous, even inhabiting the same repositories, we may still more easily admit that a Cretaceous fauna and a Tertiary flora have sometimes succeeded each other in alternate strata. It is all that is proved by the researches of Prof. Cope in relation to my own.*

From the same considerations I continue to admit the Lignitic of Vancouver Island as Eocene, on account of the character of its fossil leaves, the abundance of palms, etc., even against the assertion of Dr. Newberry, that this formation is Cretaceous. These leaves were sent to me by Dr. Evans in 1858, and my opinion of the Tertiary age of these fossils was, according to his letter, in perfect concordance with his views, and with the evidence furnished to him by his geological or stratigraphical

* In the north of France, Eocene beds are overlaid or mixed with strata bearing remains of Cretaceous animals which all disappear to the south. On this Saporta remarks that the Cretaceous fauna has persisted for a longer time toward the north. The same observation, precisely, could be repeated on comparing the Lignitic of Colorado with that of Wyoming.

observations and by the fossil mollusks. From a recent re-examination of these leaves, I find no trace among them of any species which could be compared and referred to Cretaceous plants known till now. They bear the characters of the Eocene flora, while those of Bellingham Bay, which I considered at first as of the same age, appear referable to the Lower Miocene or to an upper stage of the Eocene by the predominance of serrate leaves: *Planera*, a large species of *Salix*, *Quercus Gaudini*, recognized in the Upper Miocene of Italy, *Diospyros lancifolia*, abundant at Evanston, etc. The presence of Cretaceous animal fossil remains, above the coal of Vancouver, could merely indicate the same disagreement between the vegetable and animal remains as at Black Butte.

From the descriptions of the species of so-called Miocene plants published in Dr. Newberry's notes on Ancient Floras, etc., it is evident that the specimens furnished to him for examination have been mixed, or have come from different localities, and represent different horizons. He has, as Upper Miocene, a preponderance of Coniferous remains, especially *Taxodium distichum*, *Thuya*, *Glyptostrobus*, and *Sequoia*, which all abound in the shale specimens sent this year by Profs. Hayden and Cope from South and Middle Parks, as they have been sent before from Elko Station and Green River with *Planera*. He has *Populus Arctica*, species of *Alnus* and *Corylus*, in common with the Middle Miocene of Carbon. With Evanston he has the fine *Carya Antiquorum*, which abounds there, *Juglans rugosa*, *Platanus nobilis*, etc.;* and with the Lower American Eocene he has *Platanus Haydenii*, *P. Raynoldsii*, *Cornus acuminata*, which I consider as identical with *Juglans rhamnoides*, and, too, the same large proportion of *Sabal* leaves. In the collections brought from long explorations extended over wide areas, the mixing of the specimens is unavoidable, and personal explorations only give full evidence in regard to the information furnished by paleontological data. In my first examination of Prof. Hayden's specimens, which too were somewhat mixed, I made a mistake of the same kind, accounting for difference of types in local floras by a difference of temperature, while it merely indicated different horizons. My explorations of the past two years have therefore forced me to modify some of my views on the distribution of our Western Tertiary flora, and to fix, for the present at least, the groups in the following order, as published in Prof. Hayden's report of this year.

1. The Lower Lignitic: that of Black Butte, the whole Colorado basin as far south into New Mexico as the Placière anthracite coal has its flora, *Eocene*: Lower Eocene for America.

* These fossil plants of Dr. Newberry are known to me by the examination of the specimens from which the species are described, and which I have compared in the museum of the Smithsonian Institution.

2. The Evanston coal is, by its types, half Eocene, half Miocene, referred as yet to the Upper Eocene.

3. The flora of Carbon is positively Middle Miocene.

4. That of Green River, Elko Station and the Parks is of Upper Miocene type.

Having thus fairly considered and answered all the critical observations of Dr. Newberry, I will end the discussion by passing over to his ground and proposing a single question which I should like him to answer.

He positively regards the New Mexico Lignitic as Cretaceous. From his admission, the Colorado Lignitic is of the same formation; for, though he says that he has not seen it, he is positive that a number of geologists have found there Cretaceous animal fossils. As the Wyoming Black Butte coal has the *Deinosaurus* imbedded in its roof shale, this bed, like the underlying Lignitic, is also Cretaceous. It is therefore a single undividable formation. Now, we find at Black Butte, together with a great abundance of Sabal leaves, a number of the species described by Dr. Newberry in his Ancient Floras; *Cornus acuminata** is especially abundant there. With this we have too the fucoidal remains and, more numerous than any other species, the *Halymenites.* At Golden, we have a still larger preponderance of Sabal and of Fucoids too, and preponderance of *Platanus Haydenii*, *P. Raynoldsii*, the same *Cornus acuminata*, *Rhamnus elegans*, etc., etc. All these species, according to Dr. Newberry, are positively Miocene. This comparison could be pursued in the same way at the Raton Mountains, with the same result: Plants, Fucoids, and Cretaceous mollusks (which of course prove to Dr. Newberry that the formation is Cretaceous), and at the same time, in the same strata, those leaves identical with the species described by the same author from the Upper Missouri, and which to his knowledge represent the Miocene. Which then will he prefer? If these strata are Cretaceous, his plants of the Upper Missouri are Cretaceous plants, a supposition which he can not admit. If he insist that they are Miocene plants, our Lignitic formation is Miocene as a whole, and here he will meet all the geologists and paleontologists whom he has quoted as authority, and his own assertions too, far more antagonistic to his Miocene than they are to the Eocene of mine.

It will not do to say that a Cretaceous Lignitic flora may have some Miocene species and be Cretaceous all the same, especially when no Cretaceous species is recognized in it. After all the points of comparison and the facts mentioned in these remarks, after the assertion of Dr. Newberry that the palm leaves are evidently Miocene and the *Halimenites* as evi-

* A species far different from *Cornus acuminata* Web.

dently Cretaceous, the occurrence of these two kinds of vegetables in contiguous strata (the Fucoidal remains being even found higher than the Palm leaves), thwarts any attempt to a conciliation of this kind. It will not do either to say that the Lignitic represents at one place the Cretaceous, at the other the Miocene; for, even considering the assertion of Dr. Newberry contrary to mine, that vegetable paleontology has nothing to say in this matter, animal paleontology has sufficiently proved the continuity, the uniformity and homogeneousness of the formation.

These remarks have to be limited to what is directly related to the age of the Western Lignitic flora, and even in a paper like this I have to present them in a condensed form and without the details which might have given some more light to the subject. Those who are interested in this matter will find it discussed at length in Dr. F. V. Hayden's Report of the explorations of 1873. I will omit also to consider the speculations on the wanderings of the Floras in Europe during the geological divisions of Cenozoic time. We have enough to do and more pressing work in the study of our own materials. As the European paleontologists know very little as yet of their Eocene floras, and nothing whatever of their Pliocene, all those theories on the "march and countermarch" of the floras according to the upheaval of chains of mountains are merely imaginary.

Columbus, Ohio, April 14th, 1874.

Art. LII.—*On Helderberg Rocks in New Hampshire;* by C. H. Hitchcock.

[Concluded from page 476.]

Littleton area of Helderberg.

I have a number of sections crossing this area.* The first is one at the northeast extremity, extending from Palmer to Burnham's Hill, nearly one and three-fourths mile. Palmer Hill is composed of Lyman schist, dipping 78°, N. 28° W. This and the following are compass courses. In passing to the depression (which is in reality a watershed for the streams flowing northerly and southerly), the strata first stand perpendicular; they then dip northwesterly; and finally several measurements in a distance of thirty rods gave S. 34° E., 80°, S. 10° E., and 85°, S. 35° E. The rock here (Closson's) is an indurated slate, chiefly siliceous. Next we pass up a hill, over the Lisbon

* The courses of all the sections are indicated upon the map, page 471.

schist perhaps, dipping 80°, S. 15° E. On top of the hill there is a siliceous rock, which from different observers has received the names of sandstone and buhrstone; it dips sometimes northwest, but perhaps oftener to the southeast. On the north slope of the hill, the sandstone varies in position from about 80°, S. 8° E. to S. 8° W. This rock can be followed a mile northeasterly across the road going eastward to Mann's Hill, and then is supposed to turn and follow up the hill to the southeast of Burnham's house, and to continue southwest to Parker River. It has its maximum development on the east side of the basin, constituting what would be called a mountain range in many parts of the country. It probably connects with the buhrstone of fig. 3.

Overlying the sandstone, as I suppose, is the fossiliferous limestone. It has been excavated at several places quite extensively, and burnt in a contiguous kiln. It is usually of a light drab color, somewhat brecciated, and the fossils are not conspicuous, but upon search they prove to be considerably abundant; the thickness varies from ten to fifty feet. On the north side, the limestone forms a precipice of twenty feet, in consequence of excavations. In contact with it on the section line is a slate dipping S. 20° E. I find it also stated in my notebook that there is there a chloritic rock and a rough mixture of quartz and feldspar, and also the fact of a change of a quadrant in the strike, in a few rods distance. The overlying slate is seen to best advantage in descending the hill toward Littleton. It is rather dark, soft, splits readily and contains fucoids and markings like *Chondrites*, and dip ssoutheast. The top of this hill is an excellent place to observe contorted strata, and on account of their variation in position it is difficult to be satisfied with any interpretation of them. Professor Dana visited this locality, as well as the region along Parker Brook, in 1871.

I do not suppose that all the facts are indicated by so even a synclinal as appears in the figure. There may be hummocks of underlying rocks to disturb the continuity, and the strata are certainly contorted. The limestone was not observed to the east of Mr. Burnham's house, but, as the sandstone beyond has a small reverse dip, we may presume that the limestone changes with it. Still farther to the southeast gneiss occurs. The country is wooded and slopes rapidly, and would not be likely to afford good ledge exposures.

A mile to the southwest a more satisfactory section is obtained, so far as the position of the strata is concerned, but the limestone has not been observed. The west end lies in a valley, one of the tributaries of Parker Brook, and the rock is chiefly the chloritic rock of the Lisbon group, dipping a few degrees, S. 10° to 20° E. The ground is cleared and the ledges common. The junction between this rock and the slates can be seen to the best advantage near A. Mill's house. At the house the slates dip 85°, N. 10° W., and a short distance southeast 70°, S. 20° E., showing a small anticlinal where the rock was crowded hard. The schists, including calcareous limestone. a drusy rock, and diabase, dip 85° N. 70° W. At A. P. Hubbard's, exactly upon the section line, the dip is 85°, S. 20° E. The soft clay slate is thin-bedded, jointed but not contorted. The same position continues two-thirds of the way to J. Shute's house. The last third of the way, the slate resumes the dip of N. 20° W., and disturbances are common. The cleavage planes can also be distinguished from the strata in a few ledges. The quartzite is a rough-looking rock, somewhat like buhrstone, dipping even as low as 35°, N. 20° W. The band of chlorite schist is known by a specimen, and is supposed to correspond to a similar rock in the next section, holding the same position. Last of all is the gneiss, dipping at a moderate angle in the same direction, and probably underlying unconformably the whole series described. This section is 420 rods long. The slate is estimated to be 1490 feet in thickness.

The slate is continuous from figs. 2 to 3, gradually narrowing, and disappearing before reaching the section in figure 4; that which appears on the latter occupies a slightly different line. Fig. 3 crosses the best locality of buhrstone, from E. P. Miner's, upon a tributary of Parker Brook, and one-eighth of a mile north of the Littleton cemetery. It is 160 rods long. The western edge of the gneiss appears at Miner's. The chloritic layer is concealed by drift. The buhrstone crops out on the hill side; it is quartz, massive and brecciated, sometimes jaspery, opaline, with a multitude of seams covered by quartz crystals. About forty feet in thickness of it are exposed. Following up the hill, we find next the slates, the limestone being concealed by drift. It appears in place only a few rods to the south of the section. The slate is bent everywhere, and shows a tendency to contain drusy quartz. Two measured dips are 70° N. 60° W. and 85° N. 70° W. Other strikes are more easterly. The section, if continued, would pass down a precipitous hill and across Parker Brook into a swampy forest.

This is the most important of the sections, partly because it is near the travelled road to the Connecticut River west from Littleton village. It is one mile and three-eighths long. The gneiss is the Oak Hill deposit, and is in place one-eighth of a mile north of the section, with a dip of 35°–40°, N. 20° W. The chloritic rock appears next. It is close by the road, opposite the last house before reaching Parker Brook, and can be traced along the ridge extending northeast for one-fourth of a mile. The dip is 60°, N. 50° W., with a somewhat higher dip down the slope.

The fossiliferous limestone follows immediately. The first layer seems to conform with the wall rock. At the kiln, which is not fifty feet from the base, it dips 60°, E. 5° S., and also westerly. Hence there is a small anticlinal axis. Directly at the kiln no fossils were obtained; they come from a dark layer with a westerly dip nearer the brook. The *Zaphrentis* and the *Favosites* with small crinoidal fragments are found here. Geologists have searched for fossils at the kiln, and finding none have concluded that our story about them is a myth; but they should look in the right place. Dr. C. T. Jackson visited this kiln in 1841. He says: "The bed is included in mica slate, embraced on both sides by granite, which crowded the limestone in such a manner as to produce contortions of the strata. The course of the limestone, as indicated by strata marks, is N. 20° E., S. 20° W., and its dip is to the northwest." He figures the bed as enclosed between two masses of granite, but does not exhibit any contortions in the strata.*

The alluvium of Parker Brook intervenes and conceals the rock for an eighth of a mile perhaps. On the southwest side there are several outcrops of limestone—some of them containing coral masses. A slaty mass with no cleavage is mixed with it. The limestone near the first house on the west side of Parker Brook is bluish, and was at first supposed to belong to the Lisbon series—as it is not fossiliferous. It has been excavated for a kiln in years gone by. Recent researches indicate that the whole of this hillside, perhaps into Lisbon, is all of Helderberg age. The strata have somewhat of a zigzag arrangement, which need not be described in detail.

Directly beyond the brick kiln we find the chloritic rock in its perfection, dipping in the same direction with that already noted, but at a steeper angle, and the range is only thirty rods wide. At a turn in the road slate of less width, seemingly vertical, appears, and we discover imbedded in it two feet in thickness of compact crinoidal limestone. This identifies the slate with the deposit upon Fitch Hill, a quarter of a mile to the southwest, where the *Pentamerus* is found. The mingled slate and limestone extend up the hill and then across the ridge.

The chloritic rock re-appears on the section at a fork in the road, and continues uninterruptedly for three-eighths of a mile, dipping 75°–80° northwesterly. This would give a thickness of about 1,900 feet of strata. This is undoubtedly continuous to the west end of fig. 2 in one direction, and to the slate quarry in the other, a distance of about three miles.

The Fitch Hill locality was discovered Sept. 22, 1873. Mr. J. H. Huntington and A. S. Bachellor of Littleton and myself

* Final Rept. Geol. N. H., p. 108.

composed the exploring party, and Mr. Huntington first detected the presence of the *Pentamerus*. Our attention was called to the spot by Mr. A. R. Burton of the village, who had seen limestone there. It is about fifty rods southerly from E. Fitch's house, in an open pasture near the forest, and above an orchard. The first rock seen above Mr. Fitch's is the diabase,* running N. 65°–70° E., and containing a layer of white quartz. In the pasture the strike changes to nearly east and west, and this fact is made certain by the position there of the white quartz, which curves with the diabase, but may be a little nearer the Helderberg after the bend is passed than before. This is confirmed by examining the rocks east of the Helderberg range. On fig. 4 below, there are thirty rods of chloritic rock east of the slate range, but on Fitch Hill, in consequence of the transverse course of the slate, it lies on the southeast of the diabase altogether, as shown in fig. 5. To the southwest there is another outcrop of this range of diabase, because the Helderberg is cut off by it, but the fossiliferous seam again covers it when the low ground is reached, and the hard rock is seen no more.

Furthermore, the contact between the Helderberg and diabase on Fitch Hill is not a direct succession or interstratification, since there has been a sliding of one rock over the other. The removal of the turf revealed a slickensides between the two. As expressed by Pres. W. B. Rogers, who examined the locality with us a few days later, it "looks as if the limestone had backed up on to the green rock" These facts are mentioned to show our reasons for believing that the Helderberg rocks on Fitch Hill and the neighborhood overlie the Lisbon group unconformably.

The order of the rocks from Fitch's house to the very summit of the hill is well shown in fig. 5. What I have called the top of the hill thus far signifies the highest part of the cleared land. This section reaches the very summit, which is wooded. Above the Lisbon series, or the diabase, come about fifty feet of Lower Helderberg limestone, holding the *Pentamerus* and a Gasteropod, with the others mentioned by Mr. Billings. This is followed by forty or fifty feet of coralline slate; thirty or forty feet of friable conglomerate, white when weathered, like the Oriskany sandstone of New York, the quartz pebbles being of the size of kernels of Indian corn. Next is a bluish, somewhat siliceous limestone of two sorts. Then follows considerable tough, massive hornblende rock, with no signs of stratification and a strange associate of the Pentamerus limestone. On the very apex of the hill is a sandstone weathering white, but

* Prof. Hitchcock says elsewhere that his "diabase" is not known to contain labradorite, and may be some other rock; it is metamorphic.—J. D. D.

Fig. 1.—Section from Palmer Hill through Burnham's lime quarry. 1, Lyman group; 2, Palmer Hill; 3, Closson's house; 4, Lisbon group; 5, Farr Hill; 6, Quartz; 7, Helderberg limestone; 8, Slate; 9, Burnham's house; 10, Quartz.

Fig. 2.—Section from Crouch's to Shutes's. 1, Crouch's house; 2, Lisbon group; 3, A. P. Hubbard; 4, Helderberg slate; 5, Shutes's house; 6. Quartzite; 7, Chlorite band; 8, Gneiss.

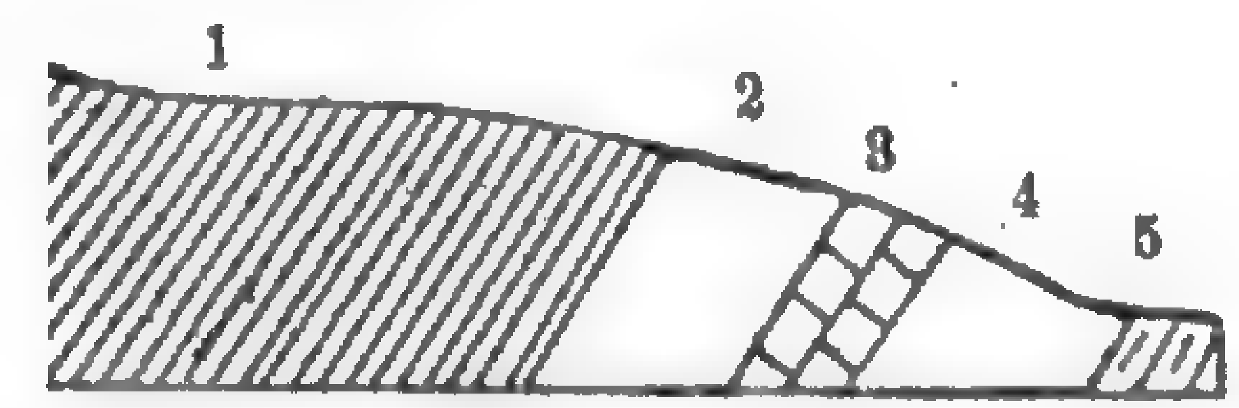

Fig. 3.—Section through Buhrstone. 1, Slate; 2, Limestone?; 3, Buhrstone; 4, Place of Lisbon group; 5, Gneiss, near E. P. Miner's.

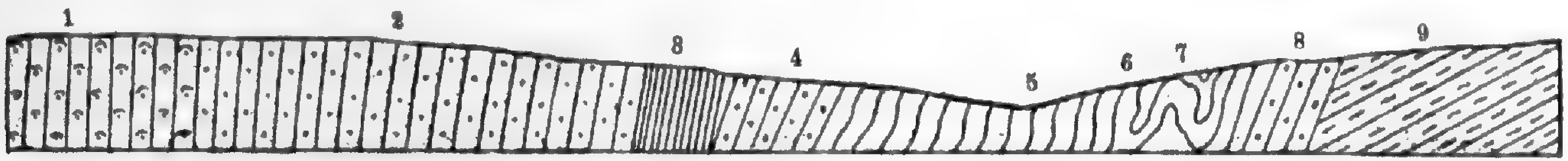

Fig. 4.—Section along carriage road westerly from Littleton village. 1, Green schists; 2, Diabase; 3, Helderberg slate; 4, Diabase; 5, Parker Brook; 6, Helderberg fossils; 7, Lime quarry; 8, Chloritic rock; 9, Gneiss (supposed).

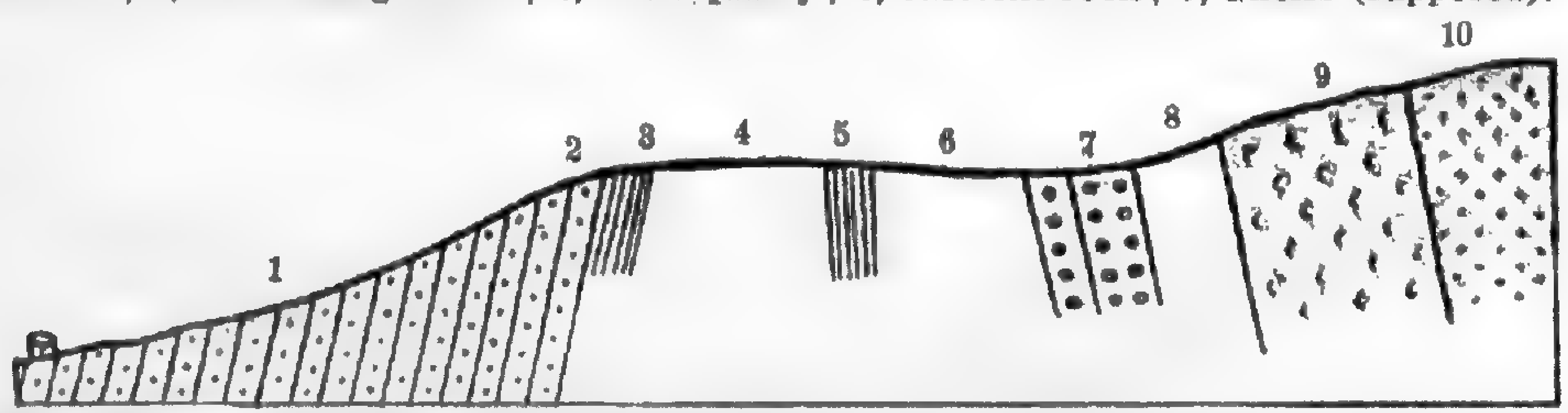

Fig. 5.—Section southerly from Fitch's house. 1, Diabase; 2, Quartz; 3, Slates; 4, Fossils in limestone; 5, Slates; 6, Limestone; 7, Conglomerate; 8, Siliceous limestone; 9, Hornblende; 10, Sandstone.

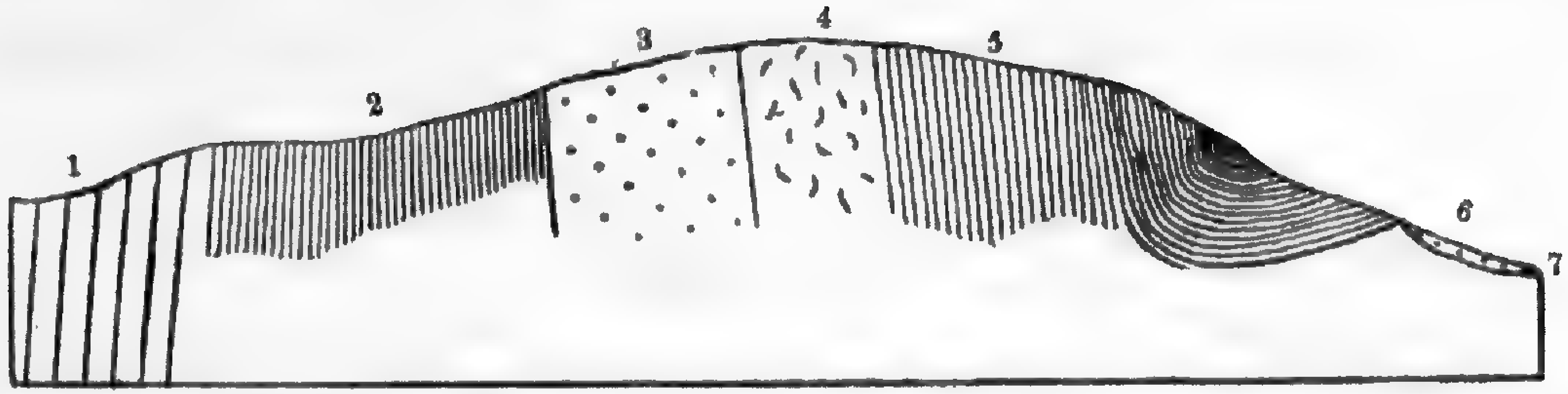

Fig. 6.—Section from Quarry Road to L. A. Parker's. 1, Chloritic rock; 2, Fossiliferous slates; 3, Sandstone; 4, Hornblende; 5, Dark slates; 6, Sand; 7, L. A. Parker's.

Fig. 7.—Section from Slate Quarry to the Ammonoosuc River. 1, Slate quarry; 2, Conglomerate; 3, Greenish schist; 4, Dark slates; 5, Light-colored sandstones; 6, Dark slates; 7, Green schists.

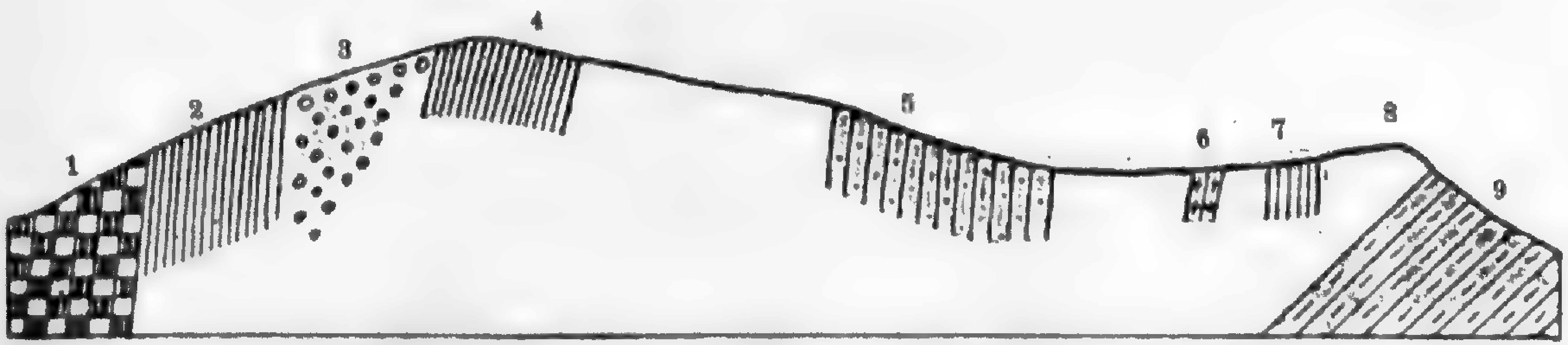

Fig. 8.—Section from Mulliken's Brook to North Lisbon. 1, Lyman group, near G. D. Shute's; 2, Helderberg slates; 3, Conglomerate?; 4, Dark slates; 5, Lisbon group; 6, Mica schists; 7, Hornblende rock; 8, Conglomerate, Swift Water?; 9, Gneiss.

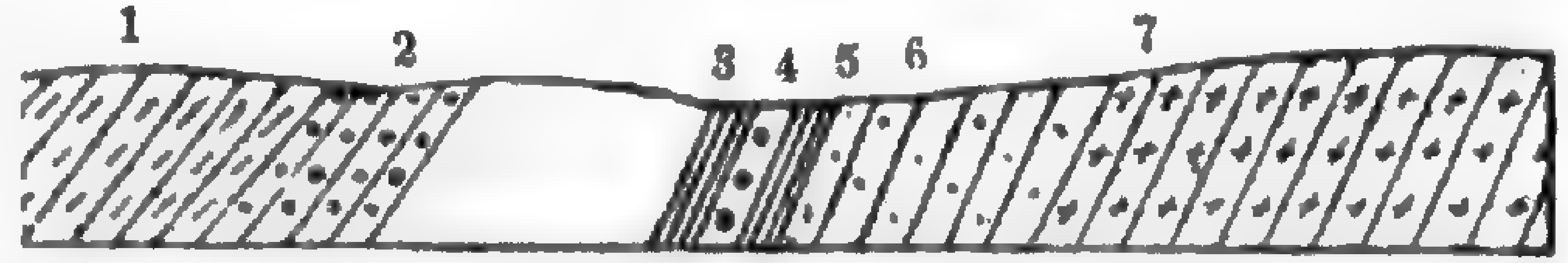

Fig. 9.—Section up South Branch, N. Lisbon. 1, Gneiss; 2, Conglomerate; 3, Slates; 4, Conglomerate; 5, Slates; 6, Lisbon group; 7, Coos group, staurolite slates.

gray in the interior. It dips apparently 50° east of north. The section is about half a mile long.

Following the limestone southwest, perhaps a fourth of a mile, we find the purest carbonate of lime yet seen. This is interrupted by chloritic rock, to be succeeded by fossiliferous slate and limestone, which passes west of the slate quarry and lower down the hill if its strike does not alter. Commencing near the fork in the road turning to the slate quarry, there is first the diabase on fig. 6, with its usual position; second, the Helderberg rocks just mentioned. The slates predominate and decompose readily and unequally. High up the hill is the gray sandstone decomposing white, continued from section 5. The hornblende rock on the crest of the hill is one massive stratum, with no indication of divisional planes. The slates were at first thought to be the continuation of the quarry ledge on fig. 7. Both have the pyrites in abundance and the same general aspect. But by comparing the several figures together, it seems as if the sandstone would correspond with the conglomerate back of the quarry, and the hornblende rocks agree with the green schist. That would make the slates just mentioned correspond with each other, as well as the harder dark slates in which a synclinal appears.

The latter slate is a hard, black, even-bedded rock, which also shows itself continuously nearly to Parker Brook. The east part of the synclinal is wanting in fig. 6, its supposed place being covered by the alluvium of the Ammonoosuc. The strike varies to northwest near Mr. L. A. Parker's house, at the east end of the section, and the rock makes a part of the zigzag arrangement before alluded to.

The next section passes from the slate quarry to the Ammonoosuc River near the south line of Littleton, one mile and seven-eighths long, and seven-eighths of a mile southwest from fig. 6. The same hill is traversed as before, but the upper slates are better displayed. They are covered by two grades of argillaceous sandstones, the lower portion being more argillaceous and of a darker color, the upper grayish and of a different texture from the sandstones on figs. 5 and 6. The hill was crossed transversely as far as indicated; the eastern slope remains unexplored. The strike varies N. 75° E. to N. 80° E. There seems to be an outcrop of the Lisbon group dipping toward Blueberry Hill in the valley east.

The slate quarry is a location known to residents on account of extensive excavations once made there. The slate is of excellent quality, and, were it not for a profusion of cubical crystals of pyrites, would be worth quarrying. It dips about 80° southeasterly. Above it on the hill is an interesting conglomerate, with pebbles averaging the size of a hen's egg. The paste is the slate of the quarry. One pebble is a foot long. Siliceous fragments of a dark color predominate, which seem to have been derived from the Lisbon group, as have been a few greenish chloritic bits. Others, and possibly the greater portion, show resemblances to the compact feldspars of the Labrador group. There are small bits of black slate like that occurring near the east end of fig. 6.

The next section in fig. 8 is three and three-eighths miles long, and passes over more strata. It commences high up the early course of Mulliken's Brook, crosses Blueberry Hill, and terminates a short distance north of North Lisbon, reaching the gneiss. At the beginning is the Lyman instead of the Lisbon group, though the latter would appear if the section had been elongated half a mile. Near G. D. Shute's house and "Indian Rock," these schists dip 85°, N. 20° W. The east border of this group dips 80°, N. 30° W. It weathers whitish, presenting a chalky aspect at a little distance. Along the carriage road succeeding is an extensive range of Helderberg slates and limestones containing *Favosites.* The strata stand perpendicular, running northeast. On a tributary stream, near C. Hastings's house, is a fine exposure of grit, slates and calcareous beds, greatly resembling fossiliferous strata in Maine and New York, but they yielded no relics of life in a half-hour's search. This series of strata forms a steep cliff seventy or eighty feet high, which can be followed a mile and a half to the slate quarry. The country at the base of the cliff is everywhere a swampy forest not intersected by roads, so that its exploration is not inviting.

Passing up the hill, there are so many boulders of conglomerate that we must believe this to be the rock in place. Its character does not vary from that seen on section 7. This view will make the fossiliferous slates correspond with the slates at the quarry. Near the top of Blueberry Hill are slates with the course N. 65° E., and irregularities which may be explained by supposing cleavage planes to be present having a different strike from the strata. On the crest of the hill the slates dip 70°, N. 25° W. This continues about half a mile on the line of section, or as far as I was able to travel upon it. There is room enough for the double thickness of slate seen in fig. 7.

The eastern slope has not been examined throughout. About half way down I have twice examined ledges apparently of the Lisbon group dipping toward the hill. Mr. Huntington travelled over the remainder of the section, and his specimens seem to indicate, first, the mica schists of the Coös group, (6) followed by considerable hornblende rock, (7) and lastly by a conglomerate (8) with whitish cement and pebbles of the size of buck-shot. This rock stands on edge on the top of the hill next the Ammonoosuc River, and, with the mica and hornblende schists, is perhaps our Swift Water series. The hornblende may connect with a large mass of the same rock a mile southwest, it being in contact with Helderberg there. The hornblende may correspond with the same rock on figs. 5 and 6. The mica schists evidently belong to the Eustis Hill series, to the south of Littleton village, possibly disconnected from that outlier by erosion.

The gneiss at the southeast end is part of the area known as "Bethlehem gneiss," or rather the common variety upon its border. The mica is black, and the feldspar often scanty. The position differs from that of the other rocks. Its normal position is about 40° dip toward the north, both the inclination and course varying from those of the other strata that have been cited.

This section, if protracted, would cross another interesting Helderberg area; but for the sake of clearness, I will add a small section (fig. 9) with greater horizontal scale, situated about a quarter of a mile to the southwest, crossing the Ammonoosuc nearly at North Lisbon railroad station and passing up its "south branch." The gneiss dips 36°, N. 35° W. at the "Lead mine." Next is a coarse conglomerate, seen in the field and under the bridge, dipping 65°–70, N. 10° W. As there is a general resemblance between this and the conglomerate of the Lisbon group, it was not till the recent discovery of extensive Helderberg strata that these ledges at North Lisbon appeared to belong to the Paleozoic series. The materials of the pebbles are white and blue quartz, hydro-mica schist or Lisbon group, two or three gneisses, Coös slates and calcareous masses, with an argillo-micaceous paste. Some pebbles are a foot long. They are usually slaty but not distorted.

Crossing the river and walking over twenty rods of gravel, we came next to a more interesting locality in the south branch valley. The first ledge, back of the last house on the road, is micaceous slate with calcareous layers, cut by an obscure igneous dike. The strata dip 45°, N. 20° W. Beneath are fifty feet of coarse conglomerate, containing, in addition to the pebbles under the bridge, pieces of the mica schist of the Coös group, without staurolite. The slates next observed have a higher dip. They are followed by indurated slates dipping 50°, N. 10° W. They are traversed by beautiful ribbons of banded trap from half an inch to three inches in width, which jump and curve in a fanciful way.

The next series evidently belong to the Lisbon group, having essentially the same strike and dip with the last mentioned beds. They extend for about twenty-five rods along the stream. The rock is a gritty hydro-mica schist, so far as seen. Probably this is the place for a hornblende aggregate or chloritic rock, which is seen on the west side of Streeter Pond *in situ*, and in enormous bowlders between North Lisbon and the pond. These hard rocks terminate just as the stream bends and passes through a narrow rocky gorge of clay slates containing staurolite and garnet, dipping 60° N. 17° W. The same dip is manifest higher up. The ledges extend for 25 or 30 rods, after which the rocks are covered with earth for a great distance. The banks are made up of bowlder clay, which is undermined by high freshets, and the road has been torn away so many times that the town authorities have been compelled to discontinue the carriage road, thus necessitating pedestrian explorations in this interesting spot. A slate similar to that just described crops out on the new road from the station to Streeter Pond, about a mile northeasterly. The course is nearly east and west, and the strata are more nearly vertical, but the ledges must be continuous between these points. It is shown also by the presence of enormous blocks of diabase, whose source must be to the north of the slates and not far distant. The map shows the distribution of all the parts of this section. The width of the Helderberg conglomerates is about forty rods, which implies a thickness of at least 500 feet. The clay slates correspond perfectly to portions of the Coös group in the Lyme and Lisbon sections, as well as to the interesting staurolite slate seen at Purple's quarry in Bernardston, Mass., described by Professor Dana.

North Lisbon Helderberg.

The rocks of the North Lisbon terrane have been described in part, but not the most characteristic ones. About 100 rods below D. Richardson's, on the east bank of the river, are white limestones containing fragments of the large crinoids. The limestone occurs on both sides of the river. These localities are southwest from fig. 9, and the limestone may prove to be one or two hundred feet thick. Mr Huntington first found these large crinoids, and we traversed the region together the last day of our stay in this region. Contiguous to the limestone is a dark slate, softer than that on Blueberry Hill, which must belong to the series. The same may be true of thick masses of hornblende rock bordering the Helderberg on the northwest flank.

Other Helderberg Localities.

There is no time to describe other localities of the Helderberg with detail. I have long been satisfied that Dalton Mountain belongs to this series, and we have strong suspicions that some of it will appear in Lancaster. A specimen obtained from one of the mountains back of the Crawford house seems to hold an obscure crinoid in it. More decided is a locality in East Hanover, where I have found a considerable thickness of slate conglomerate. The locality was visited before the first discovery of the corals of Littleton. I doubt not that scores of new localities of the Helderberg will be discovered along the Connecticut Valley, as explorations progress, since we now know what to look for.

A locality of undoubted Helderberg slates and limestones, the latter very scanty, appears in Lyman, north from the Dodge gold mine, upon a hill near D. Knapp's house. The limestones here contain small crinoidal fragments. The slate is friable, dipping 75° northwesterly, and 800 feet wide. The map shows how far they have been traced continuously to the northward, viz: nearly to Young's Pond. These slates over a part of their area contain veins of white cavernous quartz full of iron rust, which have been explored for gold. I do not think gold is found in them. They can be distinguished from the true gold quartz of this region by the absence of ankerite and the very fetid odor. North of Young's Pond are also irregular Helderberg slates.

A difficult problem has been propounded by our late discoveries, which cannot be solved satisfactorily without further explorations. From the south we carry the auriferous clay slates northeasterly, and from the north we trace the Helderberg series of slates in the reverse direction until they meet the former. They are so much alike that no effort has been made to separate them, and consequently it is impossible to say where one ends and the other begins. The boundary line must lie between Blueberry Hill and Young's Pond.

Swift Water Series.

While occupied in investigating this subject, I found a set of specimens which could not readily be referred to any of the series that have been mentioned. I had supposed them to be connected with the Lisbon group, but a careful examination of the specimens did not tend to confirm this impression. I will present a section of much importance crossing this and other groups, in a northwesterly direction, from Bronson's limestone quarry in Lisbon, through the village, and past the gold mine in Lyman, and nearly past Parker Hill in Lyman. This is the route selected for the measurement of the thickness of the Lisbon, Lyman and clay slate series, referred to above.

At the southeast end of the section, there are ordinary gneisses dipping about N. 20° W., and holding a band of azoic limestone, perhaps 100 feet thick, inclined 50°, which has been extensively quarried by Mr. Bronson. On the hillside

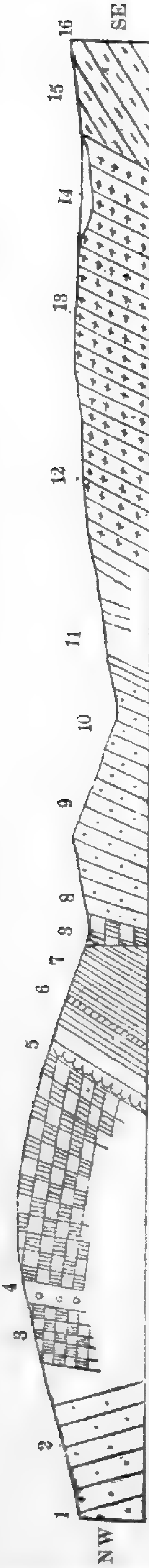

Fig. 10.—Section from Bronson's Lime Quarry to Smith's Brook, Lyman. 1, Smith's Brook; 2, Lisbon group; 3, 3, Lyman group; 4, Auriferous Conglomerate; 5, Quartz veins; 6, Auriferous quartz; 7, Clay slate; 8, Lenticular quartz; 9, Lisbon group; 10, Lisbon village; 11, Swift Water series; 12, Coos slates; 13, Coos schists; 14, Mink Pond; 15, Staurolite gneiss and hornblende; 16, Limestone.

Fig. 11.—Section through Swift Water village. 1, Starch mill, 2, Lisbon group; 3, Micaceous conglomerate; 4, Slate; 5, Gneissic; 6, Mica schist; 7, Swift Water village, chloritic; 8, Mica schist; 9, Hornblende schist; 10, Micaceous quartzites; 11, Gneiss.

toward the pond are friable gneisses, often very micaceous and carrying simple crystals of staurolite, dipping 30°, N. 60° W. This is bordered by a band of hornblende schist dipping in the same direction; 40° is the average for its whole width. The hornblende is an associate of the gneiss formation rather than of what follows. The estimated thickness of this gneissic group is 2,500 feet. It is not clear to which of the gneissic divisions it belongs, though allied to the White Mountain series in some respects.

Crossing Mink Pond is a gray, friable mica schist holding in profusion the reddish staurolites and garnets, the locality being one well known to mineralogists. The average dip being 56°, the thickness must be 3,300 feet. This band is followed by the same garnetiferous slates which have been described upon the south branch of the Ammonoosuc (fig. 9). Staurolite is less abundant in this than in the previous band, and it is almost wanting in the western portion. With an average dip of 58°, this slate must be over 3,000 feet in thickness.

The Swift Water series follows. For 140 rods there are quartzites and sandstones with an average dip of 50°, which gives 1,769 feet in thickness. More particularly, an excavation for gold at the eastern border shows slaty layers, quite siliceous, with sandstones, considerably vitrified. Next is a sandstone with whitish cement. Then there are in order actinolite schist, hornblende schist, white mica schist, and sandstone. For twenty rods beyond, the rock is purely hornblende, and is 300 feet thick. The strata are concealed for 180 rods along the line of section, which must be 2,400 feet thick, if their inclination agrees with those upon both sides. Just beyond is a black slate, exposed at a railroad crossing at the north end of Lisbon village, which is the last member of the series, and has been traced along the strike for eight miles, from near a saw-mill on Wetherbee's Mill Brook in Lisbon to the line of Haverhill. The total thickness of the Swift Water series on this section seems to be over 4,400 feet.

Attention was directed to this group partly by the slate bands and partly by a nondescript conglomerate adjoining it, particularly noticeable a mile and a half north from Lisbon, west of Mr. A. Bishop's, on the northwest side of the river. The pebbles are not discernible till the rock has been weathered nearly white, and even then it is difficult to understand their character. This band is not more than fifty feet thick.

Following up the wild Ammonoosuc River in Bath, there is a characteristic representation of this series of strata, and our name is derived from that of a small village on its banks. The facts given are chiefly from the notes of J. H. Huntington. The Lisbon group seems to extend up this stream for more than a mile above its mouth, judging from its general distribution. A little above a starch-factory, fig. 11, there are strata of micaceous conglomerate of gneissoid aspect, dipping 40° N. 53° W. The slate, or the continuation of the Lisbon band, is half a mile above the factory, and dips 65°, N. 70° W. Less than half a mile above is a more distinctly gneissic band, dipping 56°, N. 50° W. About the village of Swift Water are various exposures of a whitish mica schist, from 40° to 55° dip in the same general direction. There seems in many cases to be feldspar present; certainly a hasty look would make the ledges to be gneiss. On the north side of the river one ledge dips 50°, N. 10° E. There is a band near a cemetery in the southwest outskirts of the village containing crystals of chlorite. Passing above the village the dip rises to 80° and more, or in order, 83°, N. 42° W., and 82°, N. 62° W. The last is the most remote exposure seen. The rocks are micaceous friable quartzites, decomposing so as to appear ferruginous. There are thin, glossy black micaceous bands of a few inches in thickness interstratified with the quartzites. This is at a bridge one and a half miles above the village. A wide band of hornblende schist below the bridge should not be forgotten. The gneiss above has a high dip. It is possible that an anticlinal axis may be indicated by the divergence in the steepness of the dips. There seems to be a prolongation of a spur from the gneiss of Haverhill directly to the point of dip-divergence. There is considerable lithological similarity between the rocks along the Lisbon and Swift Water sections.

Our general impression of the age of this new series is that it is allied to the Helderberg. The Coös group disappeared finally about two miles below the Lisbon section, so that the Swift Water series lies contiguous to gneiss of a very ancient period for five or six miles. Were the presence of chlorite an index to its age, it would be ranked with the Lisbon group. No one need be disturbed by the apparent dip both of the Coös and Swift Water groups, as well as of the Helderberg strata beneath the Lisbon series; for the lateral force has been exerted so forcibly in New Hampshire, that inversion is the rule rather than the exception. There is no time to present a formal proof of this statement at present.

Conclusions.

Briefly stated, the following conclusions respecting the relations of these Ammonoosuc Helderberg strata seem to be sustained.

1. The fossiliferous limestones belong to the Lower Helderberg.
2. The Helderberg series in New Hampshire is several thousand feet thick, and is composed chiefly of limestones, slates, sandstones, conglomerates and probably hornblende rock. Some of the members are highly metamorphic.
3. These Helderberg strata seem to be newer than the Coös group of the neighborhood, since they contain pebbles derived from the latter series. The lithological character is also different.
4. The Swift Water series seems more nearly related to the Helderberg than any of the other formations.
5. The Helderberg rocks are the newest in this terrane, and the most modern that have yet been discovered in the State.

I propose next to describe the Helderberg strata and associated rocks of Hinsdale, N. H., and Vernon, Vt., as they continue northerly from Bernardston and Northfield, Mass.

Art. LIII.—*On Wheelerite, a new Fossil Resin*; by O. Loew.

During the past season's field-work of the explorations and surveys west of the 100th meridian, under the command of Lieutenant George M. Wheeler, to which expedition I was attached as chemist, many interesting chemical facts were observed. Among these may be mentioned the occurrence of a new fossil resin, whose name heads this article. This resin, which is yellowish in color, was frequently found in the Cretaceous lignite beds of northern New Mexico, filling the fissures of the lignite, and even interstratified in thin layers with the same. More of this substance was seen in the vicinity of Nacimiento than in any other locality. The strata of lignite, slate and clay, in the numerous sandstone mesas of this region, are plainly to be seen in passing by. The behavior of this resin with reagents and the analysis made proves this to be a new compound, heretofore undescribed.

On treating the resin with alcohol, the principal portion is readily dissolved, while a small part remains insoluble. The hot alcoholic extract of the resin deposits, on cooling, a few yellow flocculi. After the separation of the solution from these flocculi, there remains, after evaporation, a yellowish resin, which is very brittle and becomes strongly electric on friction. This resin melts at 154° C. At a higher temperature it emits an aromatic odor, burns with a smoky flame, and leaves a voluminous coal behind.

It is soluble in ether, less so in bisulphide of carbon. It dissolves readily in concentrated sulphuric acid, producing a dark brown solution. From this solution water precipitates it. It forms a compound with potassa in aqueous solution, and is precipitated by acids unchanged. Strong nitric acid readily oxidizes it, with the evolution of nitrous fumes.

0·106 grm. gave 0·284 carbonic acid and 0·076 water.
0·101 grm. gave 0.270 carbonic acid and 0·071 water.

The data give the formula C_5H_6O.

	Theory.	Experiment.	
		I.	II.
Carbon,	73·11	73·07	72·87
Hydrogen,	7·31	7·95	7·88
Oxygen,	19·58		

The true molecule of the resin is probably 5–6 times larger than the above formula expresses. Many fossil resins have been investigated; but none identical with the above, so far as known, has been described.

The retinic acid of Johnston, which he obtained by extracting the retinasphalt of Bovey with alcohol, is the only combination that bears a resemblance to the substance under discussion. This has the formula $C_{40}H_{45}O_6$; is slightly soluble in alcohol, readily so in ether, and melts at 120° C

I have taken the liberty of naming this new mineral after Lieutenant George M. Wheeler, Corps of Engineers, U. S. Army, the honored and energetic leader of the expedition to which I am attached.

Laboratory of the Smithsonian Institute, Washington, D. C., March, 1874.

Art. LIV.—*The "Great Conglomerate" on New River, West Virginia;* by Wm. M. Fontaine.

[Concluded from page 465.]

This series, while in some features resembling the overlying Lower Coal rocks, is distinguished by the almost entire absence of shales, notably in connection with the coal beds. We find no well developed under-clays with the coals, and no shales overlying them, features strikingly characteristic of even the lowest bed of the Lower Coal rocks. The seams are enclosed in flaggy sandstones; and all their accompaniments show that they were formed in an era of sudden and violent changes. The beds, followed from outcrop to outcrop, vary much in thickness, showing sometimes, in short distances, a change of several feet. These rapid changes are the only unfavorable characteristic. I could find no specimen of coal sufficiently fresh to give me a good idea of the mineral. Rogers, in his analysis, makes them remarkably free from ash, and with much less bituminous matter than the beds of the Lower Coal series. From the weathered appearance of the bed which I examined in detail, the proportion of sulphur is large, as we might expect from the antiquity of the formation.

The following measurements, kindly furnished me by Mr. Maury, were taken a short distance east of the point examined by myself. They will thus serve as a description of the coal beds at the station. The railroad here runs about 50 ft. above the level of the river.

Distances above the railroad.	
495 ft.	2 ft. seam.
595 ft.	4 ft. "
635 ft.	2½ ft. "
647 ft.	8 in. "
747 ft.	2½ ft. "
847 ft.	1 ft. "
1125 ft., over massive sandstone,	4 ft. 10 in. seam.
1315 ft.	4 ft. 6 in. "

The two highest seams occur in the base of the Lower Coals; and these coals, with their enclosing rocks, must, as stated before, be added to the base of the Paint Creek section, leaving an unknown interval between. The lower of these, the 4 ft. 10 in. bed, lies about 50 ft. above the massive sandstone; hence the top of the rock would stand 1,075 ft. above the railroad. This rock itself in this section is about 150 feet thick.

The third seam is a good example of the fluctuations in thickness of the coals of this system. On the road, near the station, it is only 7 in., probably from a slip. About a mile above the station, it shows an outcrop of $4\frac{1}{2}$ ft. It was here opened, with the view of shipping coal on an extensive scale; but, on following it into the hill, it pinched out to a few inches, and the work was abandoned, the party next opening the first seam above the Conglomerate. The Conglomerate seam is composed of alternating laminæ of dull black charcoal and brilliant black portions. It is much fractured, and somewhat friable, showing sulphur abundantly in weathering. The junction of the roof with the coaly matter is extremely sharp and well defined. The roof is composed of flaggy sandstone, with many well-preserved impressions of plants. The floor is composed, not of the usual fire-clay, but of a curious conglomerate, consisting of rounded fragments of fine grained grey sandstone, and a very fine gray shale, all cemented by shaly matter colored with coaly matter. The shaly fragments are something like the blue shale mentioned as occurring lower in the series.

The plants found in the roof deposits merit careful exploration. I had a very short time to devote to the collection of them.

Alethopteris Serlii is the most abundant. Both varieties, α and β, occur. Next in abundance is *Neuropteris Dawsoni*, of which I obtained several good specimens and one entire leaf, with fragments showing a peculiar union at the bases of adjoining leaves. It would seem that two adjacent pinnules met at their bases under a very acute angle, when the two midribs were fused into a common rachis, which was broadly winged and seemingly partly clasping in its mode of attachment. Also, more rarely, we find *Sphenopteris obtusiloba*, *Sphenophyllum antiquum* and *Cyclopteris Jacksoni*.

We need not be surprised to find so large a proportion of Devonian plants so close under the lower coals; for, as we shall see, there was probably an uninterrupted land flora in some portion of this region, extending from the Chemung up to this era.

As has been stated, the section at Sewell does not expose the base of the Conglomerate series. On passing to the east, up stream, the constant northwest dip brings up lower and lower strata, until another heavy white sandstone, much like the topmost ledge, is exposed. This portion of the formation I had no opportunity to examine; and hence I cannot give the precise eastern limit. I think, however, that this last rock may be taken as the base; for it indicates a decided change in the conditions controlling the next lower deposits. These, which appear in succession to the eastward, are heavy-bedded sandstones; but now they assume reddish and brownish colors, and are interstratified with red shales. Some of the sandstones still retain their conglomeritic texture; but none is seen beyond Stretcher's Neck Tunnel, a point some eight or ten miles east of Sewell. These rocks of passage, as we may deem them, are succeeded by the brilliantly colored red shales of the Subcarboniferous formation, which are greatly developed in this region. Rising from under them appears a great limestone formation, which is the base of the Subcarboniferous in Virginia, and which appears in great force around Lewisburg. While it is difficult to fix the eastern limit of the Conglomerate with exactness, owing to the blending of its base with the top of the enormously expanded Subcarboniferous formation, Rogers states that the following is the approximate boundary. In the north of the State, in Hampshire and Hardy Counties, it is in the east Front Ridge of the Alleghany; in Greenbrier and Monroe Counties, in the Greenbrier and Muddy Creek Mountains; and farther south, in the Great Flat Top Mountains.*

In accordance with the above statements, we see that this lowest coal series on New River exhibits a triple structure, with a summit and base of conglomeritic sandstones, and a central portion of more argillaceous rocks, which contains beds of coal. If we compare this arrangement with that shown by the Conglomerate in other portions of the country, we shall find that it is the typical arrangement of this formation, wherever it attains a considerable development. We shall also find that the thickening of the whole formation is mainly due to the expansion of the middle portion, and that the increase in the amount of coal closely follows such expansion. It may not be amiss to give a brief description of the Conglomerate at a few other points, in order to confirm these statements.

At its northwest extremity, near Franklin, Pennsylvania, Prof. Rogers shows that the Conglomerate has nearly thinned out, and has no intervening argillaceous portion. The two bounding sandstones have come in contact. To the southeast, at Broad Top Mountain, it is, according to Lesley, less than 200 ft., still containing the upper and lower arenaceous portions, but now, in accordance with its increased thickness, containing a central argillaceous portion, with a small development of coal.

Near Morgantown, at Laurel Hill, we have the triple arrangement, with an entire thickness, according to Dr. Stevenson, of about 350 ft. Near the center of the formation here, according to a local geologist, occur two beds of coal, the lower 15 in. and the upper 15 inches to 3 feet.

The nature of the formation on New River we have already considered.

Followed to the northeast into the anthracite fields, we find a great expansion, with a corresponding development of the mid-

* The details of the general geology of the country, given in this paper to illustrate the relations of the "conglomerate," are mainly derived from Wm. B. Rogers's Virginia Reports.

dle portion and the accompanying coals. Owing to the great coarseness of the rocks here, the sandstones of the central portions are often true conglomerates. It is in the anthracite region only that the entire thickness of the Conglomerate can compare with that of the rocks on New River. Were it not that almost all of the Lower Coal series has been swept off, where the conglomerate rocks are exposed on this stream, the amount of coal present in the two formations here would not be inferior to that exposed in Pennsylvania; but the greatly increased number of seams would prevent any one from attaining the great thickness of some of the anthracite beds.

In accordance with the comparison just made, it would seem that the Conglomerate expands in two directions. If we select a point at the north of the State, such as Westernport on the Potomac, and trace this system of rocks to the northwest into the Sharon coal field in Pennsylvania, we shall find it thinning out rapidly; but, if we proceed to the northeast into Pennsylvania, or to the southwest in West Virginia, we find a very marked expansion. This diminution to the northwest from the above-mentioned vicinity, and thickening to the northeast and southwest, will be found characterizing some of the formations preceding the Conglomerate. It is a noteworthy fact that, in each case, the expansion to the southwest is attended with an increased formation of coal. Prof. Wm. B. Rogers has already called attention to this fact, in respect to the Subcarboniferous and Catskill. This increase of thickness to the northeast and southwest from a fixed point, commencing in the Devonian period, seems to have continued, with some modifications, into the Lower Barren measures of the Carboniferous period. We have seen that, to the southwest, on the Kanawha, the greatly increased thickness of fragmental rocks in the lower coals is accompanied by a great increase of coal. On the Potomac, in the vicinity selected as our initial point, both the entire thickness of the Lower Coal series and the amount of coal are far less.

Wm. B. Rogers has identified the Pittsburg seam near Westernport, and places it about 600 ft. above the lowest coal bed of the Lower Coal series. This would give at this point a little more than 600 ft. for the Lower Coal series and the Lower Barren measures united. He gives no separate measurements for either; but, from the position in which he finds the coal beds, the greater part of this thickness belongs to the lower coals. This is confirmed by the investigations of H. D. Rogers, at Elk Lick, Pa., where he finds 300 ft. of Lower Coal-measures, and 200 ft. of the Barren measures. This shows a considerable diminution of the latter eastward, for we find them 450 ft. thick at Morgantown; and near Caledonia, on Bennett's Branch, in Pennsylvania, to the northeast they measure 500 ft.

In the Lower Coals at Westernport, Wm. B. Rogers gives four coal beds, averaging in the aggregate about 15 ft. One of these is very insignificant (15 in.), and variable. If now we compare the Lower Coal series at this point with the thickness of the fragmental rocks and coals shown over the conglomeritic portion of the anthracite fields of Pennsylvania, we see that the series has expanded to the northeast no less than to the southwest.

While the above facts indicate that the Lower Barren measures thin out to the east, we do not find that they obey the same law of diminution with the older formations, at least to such an extent as the latter. Still, we find that the increased rate of deposition of sediment to the northeast and southwest of the northern portion of West Virginia is not entirely changed. Selecting Morgantown for our point of comparison, since we have no measurements for places farther east, we find the Lower Barren measures here 450 ft. To the northeast, in Pennsylvania, on Bennett's Branch, we find them 500 ft.; while below Charleston, on the Kanawha, we have, as I have shown, good reason to think them over 500 ft. thick. This comparative uniformity of thickness leads us to think that we have, in these rocks, no longer formations fringing a continental mass, as would seem to be the case with the older formations.

We can, I think, detect, in some of the formations underlying the Great Conglomerate, a similar mode of expansion.

From what has already been said in connection with the eastern limit of the Conglomerate on New River, it would seem that the formation cropping out from under it, the Subcarboniferous, has also in that region a great expansion. This is proved by the measurements of Prof. Rogers. He states that a triple structure marks the formation everywhere in the State. At the top, we find brownish and greenish sandstones, with interstratifications of shales; in the middle, red and green, soft, decomposing shales; at bottom, limestones. Measured on the Potomac, near Westernport, we have, for the whole formation, 918 ft. with 80 ft. of limestone. In Greenbrier County we have, for the entire thickness, 2,132 ft. and 822 ft. of limestone, with hardly any shaly seams. To the northeast in Pennsylvania, we have, in the anthracite region, a thickness of 2,500 to 3,000 ft., almost entirely red shale. As usual, the expansion to the southwest is attended with a great increase of coal. There would seem to have been two eras of coal-making. In the top of Little Sewell Mountain, Rogers found a bed of coal close under the Conglomerate. This seems to be the equivalent of the Sharon coal of Pennsylvania, and if so, indicates a remarkable persistence for this slightly developed series.

Lower down in the sandstones and shales, a much more important formation of coal took place, giving rise in the vicinity of Lewisburg, and west of that town, to a bed of four feet in thickness. Still more developed are these coals in Montgomery County, where we have two beds, the lower 2–3½ ft., and the upper 6–9 feet thick; much of the latter being slate.

The strata of this formation in Pennsylvania thin out rapidly to the northwest, just like the Conglomerate, according to Rogers. A line drawn in that direction, from near Westernport, indicates the direction of diminution.

The next formation beneath, viz: the Catskill, will be found to change in a manner precisely similar to the above-mentioned deposits, but in degree even more striking. The following are the measurements of Wm. B. Rogers for West Virginia

On the Potomac, near Westernport, he finds it 200 feet thick. In this part of the State a thin seam of coal presents itself, but often thins out and is lost. To the southwest, near Lewisburg, it is 800 feet thick, with the coal much more developed, attaining in one place the dimensions of nearly four feet.

This formation to the northeast thickens much more rapidly, being, according to Dana, 2,000 to 3,000 feet in the Catskill Mountains.* To the northwest from the Potomac, it rapidly thins out. About six miles east of the White Sulphur Springs the cuttings for the west approach of Lewis Tunnel disclose a very impure bed of coal, about 12 inches thick, which at the opposite end of the tunnel has degenerated into a black bituminous shale. It is uncertain whether this bed occurs in the Chemung or Catskill. If in the former, it must be near the top, close to the latter formation. The rocks immediately to the west, toward the Alleghany main range, show characteristic Chemung fossils in the float rock on the surface; but in the short examination which I made, to discover the fossils in place, I did not succeed in so doing. These strata are very highly inclined and differ in character from those containing the coal. The latter also dip less steeply, and are apparently unconformable with those lying more to the west.

The slates accompanying this small coal seam contain many beautifully preserved Devonian plants, which confirm the supposition of the Catskill age of the strata. Among the plants here preserved are several species of *Lepidodendron*. *Cyclopteris Jacksoni*, *Noeggerathia obtusa* and *Neuropteris flexuosa* also occur. Of the two latter I saw magnificent specimens; I was much surprised to see so finely marked a specimen of *Neuropteris* at this low horizon. *Cyclopteris valida* is common, also species of *Pinnularia*. Among the *Lepidodendra* is *L. Gaspianum*. I was enabled to collect but few of the plants, and have not yet had an opportunity to study them thoroughly. The locality,

* Prof. Newberry and others consider that the greater portion of this mass is Chemung. This agrees better with the expansion of the coal to the S. W.

however, well deserves a careful examination, although the best specimens have been carried off by mere curiosity-seekers.

It would thus seem that the great expansion of the Conglomerate on New River is not an isolated phenomenon, but that it is the effect of a condition of things which began in much older formations, and continued until a later era. The question is suggested: Does not the successive formation of coal on an extended scale, along the southwest border of the Appalachian coal field, commencing in the Devonian period, point to the existence at this time of a continental mass nearer than the Azoic of Canada?

Morgantown, West Virginia.

ART. LV.—*Contributions from the Sheffield Laboratory of Yale College*, No. XX. *On a Feldspar from Bamle in Norway;* by GEORGE W. HAWES, Ph.B.

ASSOCIATED, at Bamle in Norway, with the fluo-phosphate of magnesia and lime which has been called by v. Kobell Kjerulfine, is found a triclinic feldspar. It occurs massive, with two cleavages at an angle of 94°. Upon the more perfect cleavage surface are very fine striations. Its luster is vitreous; color grayish white; semi-transparent. H.=6. G.=2·67. When heated it phosphoresces with a white light and fuses, at about three, to a translucent glass. It is unacted upon by acids, until boiled for a long time, and then but slightly. When heated in a matrass, the tube is dimmed by moisture. The analyses were made according to the usual methods, and gave

	I.	II.
Silica,	66·04	66·05
Alumina,	20·33	20·41
Ferric oxide,	·29	·28
Lime,	1·29	1·30
Magnesia,	1·11	1·08
Potash,	·21	·21
Soda,	10·01	9·81
Ignition,	·95	·96
	100·23	100·10

Oxygen ratio for $\dot{R}$, $\ddot{\bar{R}}$, $\ddot{Si}$, 1 : 2·8 : 10.

This analysis shows the mineral to be near oligoclase, if not identical with that species. Its association and its physical properties are the same as those given by v. Kobell for Tschermakite, recently described as a new species of feldspar.* In the specimens examined, which were from the cabinet of Prof. Brush, the feldspar occurred in quite large fragments, so that it was possible to extract it in a state of purity.

* Ber. Ak. München, Dec., 1873; this Journal, March, 1874.

ART. LVI.—*Notes on some of the Fossils figured in the recently-issued Fifth volume of the Illinois State Geological Report*; by F. B. MEEK.

[Concluded from page 490.]

Edmondia ovata; pl. XXVI, fig. 13.—At the time the figure of this shell and the explanations of the plate were prepared at Springfield, being in doubt in regard to its relations to one of the Nebraska species, of which there were no specimens or other means of comparison at hand, I merely wrote with a pencil, provisionally, opposite its number on the explanations of the plate, the name *Edmondia ovata*, which was also in the same way attached to the specimens. The intention was, at the time, to make thorough comparisons with the Nebraska shell in preparing the text for the press. As this intended revision and preparation of the text was prevented by sickness, however, the merely provisional name was, as in some other cases, printed as originally written.

Since the publication of the report, I find, on comparison, that this shell is so nearly like the Nebraska form I have called *E. subtruncata* (Paleont. E. Nebr., p. 215, pl. II, fig. 7), that it may be only a variety of the same. It is proportionally a little longer, and has its beaks somewhat more distant from the anterior end, which is rather more broadly rounded in outline. It may be a distinct species, but I should have hesitated to name it as such, had I been able to make the comparisons and intended revision before the report went to the press.

Schizodus Rossicus de Verneuil; figs. 17*a–e* and 18*b*, *c*, pl. XXVI.—The shells represented by these figures are so nearly like those referred by Prof. Geinitz, in his work on the Nebraska fossils, to *Schizodus Rossicus*, originally described from the Permian rocks of Russia, that little if any doubt can be entertained in regard to their identity, at least, with the Nebraska specimens. In the Report on the Paleontology of Eastern Nebraska, I referred the Nebraska City shells, with great doubt, to *S. curtus* M. & W., from the upper part of the Coal-measures at Grayville, Illinois; stating that, "without intending to express a positive opinion in regard to the relations of these two forms, I have concluded to refer the Nebraska City specimens, provisionally, to *S. curtus*." I noticed, and stated, that the Nebraska specimens are more compressed than the Illinois species, but could not quite get rid of the impression that this might have resulted from accidental pressure, as the specimens were nearly always found lying on one side or the other, on the surfaces of separated laminæ of argillaceous rock.

In subsequently studying the Illinois Coal-measure fossils, however, I soon found that there is there, even in the lower part of the Coal-series, a slightly variable shell, agreeing well with the Nebraska City species, and yet readily distinguishable by its *constantly* more compressed form, and less prominent beaks, from *S. curtus.* Being, at the time the plates were prepared, undecided what disposition to make of these more compressed forms, I merely wrote, temporarily, the name *S. Rossicus* de Verneuil ?, opposite their number on the explanations of the plate, intending ultimately to study them more carefully, before coming to a final conclusion in regard to their relations. The opportunity to do so, however, was prevented, as elsewhere explained, and the name printed in the explanations of the plate as at first provisionally written.

That these shells are really identical, however, with the Russian Permian species *S. Rossicus,* is, I think, extremely doubtful; though they nearly resemble that species in form; and there is, according to Eichwald, a shell sometimes found, in the Carboniferous rocks of Russia, that he could not distinguish from *S. Rossicus.* Still, in a genus like this, where the species often closely resemble each other, and present few external distinguishing characters, excepting the often variable one of mere form, it is perhaps nearly, if not quite, impossible, in many cases, to determine beyond doubt the exact relations between closely allied forms, until their hinges and interiors can be carefully compared.

While looking over the Illinois collections, I was fortunate enough to find two specimens of the compressed form represented by our figures (see fig. 17*c*, *d*), showing the hinges of both valves very clearly. An examination of these figures will show that this shell presents some rather marked differences in the characters of its hinge, from the typical species of *Schizodus,* as illustrated by Prof. King. That is, it has but two *true* teeth in each valve, instead of three in one and two in the other; while the one corresponding to the deeply bifid or split tooth in the typical *Schizodus* is only a little emarginate. According to Prof. King, however, the teeth of this genus are subject to some variations, while Prof. McCoy, who has carefully studied the hinges of the British typical species of the genus (some of which seem not to have been seen by Prof. King), says that the third tooth is often obsolete, and that the bifid one varies in the distinctness of this character. De Verneuil also describes *S. Rossicus* as having the posterior tooth nearly or quite wanting. From these facts, and the general physiognomy of our American forms, I can see no very satisfactory reasons for separating them from the genus *Schizodus.*

At any rate, whatever importance may be attached to the peculiarities of the hinge we have illustrated, so far as regards the relations of these shells to *Schizodus*, I have no doubt that the little shell from the Kansas Coal-measures, for which Mr. Conrad proposed the generic name *Prisconaia*, in the Am. Jour. Conch., vol. i, 1867, is really congeneric with our specimens. I cannot agree with my friend Mr. Conrad, however, in the opinion that these shells belong to the *Unionidæ* (*Naïades*). On the contrary, their entire combination of characters, no less than their constant association with marine types, seem to me to indicate different family relations. That is, they seem to be directly connected, through the typical *Schizodus*, and the various forms included in the genus *Myophoria*, with the *Trigoniidæ*, as maintained by Prof. King.

Yet, if farther comparisons should show that Mr. Conrad's name must be retained in a subgeneric sense, under *Schizodus*, the name of our species, represented by fig. 14*a*, *b*, *c*, will doubtless have to be written *S.* (*Prisconaia*) *curtus*, as it almost certainly has the same hinge-characters; and I even suspect Mr. Conrad's type, *P. ventricosa*, may be *specifically* identical with it.*

It will be seen, by examining our figure 17*e*, that the surface of these shells, when perfectly preserved, and examined under a strong magnifier, in a favorable light, shows very minute, exceedingly regular and peculiar sculpturing. I am not aware that any such markings have ever been observed on the typical European forms of *Schizodus;* but then it must be remembered that this sculpturing is so *extremely* minute, that it is only preserved on specimens that have been replaced by pyrites, or some other very hard mineral, and not subjected to the slightest abrasion. Indeed, so very minute is it, that it would generally escape observation, unless especially looked for. On calling Mr. Conrad's attention to it, he wrote me that he found it to be beautifully defined on the type of his proposed genus *Prisconaia*.

Solenomya (sp. undt.); pl. XXVII, figs. 1*a*, *b*.—I have long been familiar with this shell among our Coal-measure fossils of the West, but have never been quite able to come to a satisfactory conclusion in regard to its relations to a species figured and described by Prof. Cox, in the third volume of the Ken-

* I cannot agree with Mr. Tate and others, who would substitute a new name *Axinopsis*, or some other, for Prof. King's genus *Schizodus*, merely because the name *Schizodon* had been previously used for genera of Fishes and Mammals. Although *Schizodus* and *Schizodon* are etymologically the same, they are still distinct enough in sound, and to the eye, not to be confounded. It is desirable of course to avoid proposing names so nearly like others already in use; but, when it has been accidentally done, and there is no danger of confounding two such similar names, more harm results from making changes than from allowing both to stand.

tucky Geological Reports. It is certainly always narrower in proportion to its length, and has, at both extremities, different outlines from Prof. Cox's figure; while it also wants the rather distinct undulations shown on the same. If specifically distinct, it may be called *S* (*Janeia*) *trapezoides.*

We have elsewhere stated reasons for believing that Prof. King's name *Janeia* may possibly yet have to be retained for the Carboniferous and Permian species usually referred to *Solenomya* (=*Solemya*), notwithstanding the fact that Prof. King withdrew it at a later date.*

Placunopsis carbonaria M. & W.; pl. XXVII, figs. 2*a*, *b*, *c*, *d*. It is quite probable that this shell may have to take the name *Anomianella carbonaria*, as it seems to agree with a genus published under the name *Anomianella* by Rychholt, in 1852, from the Carboniferous rocks of Belgium. I have not seen a figure or good description of Rychholt's genus; but it is said to be thin, more or less oval, without any perforation in the lower valve, and to grow attached to other shells—all of which characters would appear to indicate very close relations to our species. They are, however, also equally applicable to *Placunopsis*, of Morris and Lycett, proposed in 1853 for Jurassic species. But, even if *Anomianella* and *Placunopsis* are synonymous, the above suggested change would almost certainly still be necessary, *Anomianella* having priority of date over *Placunopsis*.

Anomphalus rotulus M. & W.; pl. XXIX, figs. 10*a*, *b*, *c*.—This is the type of the group for which we proposed the name *Anomphalus*. I merely call attention to it here to correct an error into which I regret to have led Prof. Bradley, in regard to a little Illinois Coal-measure shell referred by him, not long back, to this genus, in this Journal. At the time he showed me his specimens at Washington, I had not seen the original drawings of our type (which were at Springfield, Ill.) for several years; and, from having confounded it, in mind, with another form, I supposed Prof. Bradley's shell to belong to our genus. A moment's comparison with our figures cited above, however, will show that the very broad flattened columella of Prof. Bradley's shell at once places it in an entirely distinct and, as I think, undescribed genus, probably of different family relations.†

Euomphalus rugosus Hall; pl. XXIX, figs. 11*a*, *b*, *c*.—This shell was referred by Prof. Geinitz, in his work on the Nebraska fossils, to the articulate genus *Spirorbis*. I have elsewhere insisted, however, not only that it is specifically and generically distinct from the foreign form with which Prof. Geinitz supposed it to be identical, but that we have a group of larger

* See Proceed. Acad. N. S. Philad., April, 1870, p. 44.

† See page 151 of this volume.—Eds.

species in the Coal-measures of Illinois, which appear to me to connect it so intimately with the genus *Euomphalus* of Sowerby, as to show it to be a true mollusk, if not really a species of Sowerby's genus. By comparing the figures cited above with the forms represented by figures 12*a*, *b*, *c*, 13*a*, *b*, *c* and 14*a*, *b*, *c* of the same plate, this will, I think, be apparent enough to any one.

In conclusion, I would remark, in connection with what has already been said respecting the Coal-measure fossils illustrated in the Illinois Report under consideration, that a comparison of these forms, particularly those represented on pl. XXVI, with those figured by Prof. Geinitz in his "Carbon-formation und Dyas in Nebraska," will, it is believed, clearly show that those Nebraska so-called Dyas rocks cannot be separated from the true Coal-measures upon any well-defined paleontological evidence. I have, however, so fully discussed this subject in the Report on the Paleontology of Eastern Nebraska, that it is unnecessary more than merely to allude to it here.

Pleurotomaria Gurleyi; pl. XXX, figs. *b a*, *b*, *c*.—This species was described by me in the Proceed. Acad. Nat. Sci. Philad., for August, 1871, page 177.

NOTE.—In addition to the typographical errors noted in the list at the end of the volume, the following errata should be corrected:

Page 477, 4th line from top, for "connection," read connections.
" 568, 20th line from bottom, for "γρκμμά," read γραμμή.
" 592, 2d line from top, in explanations of pl. XXVIII, and index, for "ventricosus," read ventrica; the latter being the original orthography, as written by N. & P.
" 602, 16th line from top, for "specimens," read species.
Expl. Plate IV, top line, for "Theimei," read Thiemei.
" " XIV, 16th line from top, for "small simple arms," read small simple arm.
" " XX, 4th line from bottom, for page "330," read page 530.
" " XXIX, 10th line from top, for "fig. 5*," read fig. 2*.
Lettering of pl. XXVI, lower left-hand figure, for "21*d*," read 20*d*.

It is perhaps hardly necessary to explain that the references to the Proceed. Acad. N. S., in connection with the remarks on the genera *Actinocrinites*, on page 339, *Batocrinus*, page 364, *Megistocrinus*, page 393, &c., are merely intended to designate where these remarks were first published by us, and not to refer to the original description of those genera.

Jacksonville, Fla., January, 1874.

ART. LVII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXX.—*On the Chemical Composition of the wood of Acrogens;* by GEORGE W. HAWES, PH.B.

THE following analyses, giving the elemental composition of some dried plants of the class of Acrogens, will be of interest, as showing the relationship between these and other forms of vegetable matter. It was from this class of plants that coal was mostly formed, and the analyses will therefore be of value in calculations as to the origin and formation of coal beds. Some of them have been used by Prof. Dana in the new edition of his Geology in illustration of this subject. With the exception of the stem of the Tree-fern, the plants were collected near New Haven. Average samples of the part above ground were made, including the spores, and including, in the case of *Lycopodium complanatum*, a due proportion of the trailing stem, and in the case of the fern, *Aspidium marginale*, a portion of the woody rhizoma.

The combustions were made with chromate of lead as an oxidant, but for the sake of experiment, the Equisetum and the Lycopodiums were afterward burned with the mixture of potassium dichromate and kaolin, which has been proposed as a substitute by Prof. S. W. Johnson. (See this Journal for May.)

The following were the results obtained: analyses 9 to 12 are of the tree fern, 9 and 10 of a complete section of the stem or trunk, and 11 and 12 of the exterior or "cortical" part.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Ash.	
1. Lycopodium dendroideum,	47·11	6·39	41·85	1·40	3·25	100
2. " "	47·29	6·43	41·62	1·38	3·28	100
3. Lycopodium complanatum,	45·78	6·25	40·66	1·84	5·47	100
4. " "	45·62	6·26	40·79	1·84	5·49	100
5. Equisetum hyemale,	41·94	5·89	39·23	1·12	11·82	100
6. " "	41·96	6·01	39·21	1·12	11·70	100
7. Aspidium marginale,	44·77	5·99	41·97	2·08	5·19	100
8. " "	44·70	6·05	42·03	2·05	5·17	100
9. Cyathea canaliculata, section,	45·39	6·11	39·82	1·12	7·56	100
10. " "	45·33	6·21	39·76	1·10	7·60	100
11. " " "cortical" part,	48·72	4·89	38·48	1·42	6·49	100
12. " " " "	48·61	4·95	38·53	1·42	6·49	100

Excluding the ash from these analyses, we have the following as the composition of the vegetable tissues. For the sake of comparison, an analysis by Websky of a Sphagnum, the peat plant of swamps and a member of another class of the Cryptogams, is added; and also analyses of three kinds of wood.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	
Lycopodium dendroideum,	48·79	6·62	43·15	1·44	100
Lycopodium complanatum,	48·35	6·61	43·09	1·95	100
Equisetum hyemale,	47·54	6·74	44·45	1·27	100
Aspidium marginale,	47·18	6·35	44·30	2·17	100
Cyathea canaliculata, section,	49·08	6·66	43·05	1·21	100
" " "cortical" part,	52·04	5·26	41·18	1·52	100
Sphagnum (Websky),	49·88	6·54	42·42	1·16	100
Oak (Payen),	50·00	6·20	43.80		100
Beech "	49·25	6·10	44·65		100
Ebony "	52·85	6·00	41·15		100

From these analyses it is evident that the wood of Acrogens does not differ in ultimate composition from that of ordinary forest trees, since the percentages of the constituent parts all come within the limits of variation, not only of the different kinds, but often of the same kind, of wood. Payen obtained from one specimen of hard oak wood 54·44 of carbon; and Baer from the beech obtained a percentage as low as 46·10. Their microscopic structure would seem to show that they contain about the same amount of cellular tissue.

The stem of the tree fern was brought from Tahiti by Prof. Dana. The central pith, as usual, was gone. For the first two analyses (Nos. 9, 10) a complete section of the stem was made, and sampled. For the other two (Nos. 11, 12) a portion of the outer "cortical" layer was taken. This is composed of a very hard material, much better fitted to resist force and decomposition than the soft wood and pith; and this is the part that is commonly called the bark. But it is evident that in this, as in other endogenous forms of vegetation, there is no true bark.

This cortical portion forms the support of the fronds, which on dropping away leave it as a sheath; but the section of the stem shows that the true wood of the interior is likewise surrounded by this hard substance, nearly as thick, and showing the same microscopic structure and arrangement of layers as the so-called bark. (See plates in Hugo Mohl's Essay on the Structure of the Stem of Tree Ferns, in Martius Icon. Plant. Crypt. Brazil.) Hence, although the exterior is more hard and resisting than the pith, it is not more so than much of the interior of the plant; the portions which are left finally undecomposed can not, therefore, be more correctly called bark than the exterior of the stems of Lycopodiums. Its resemblanee in composition to ebony will be noticed in the table. In the microscopic sections above referred to, small particles of resin were seen lying immediately against these hard portions of the tree fern; and the secretion of oils, camphors, resins, and other bodies rich in carbon, by tropical trees, makes its resemblance to such woods more striking, although it does not differ essentially from some of the oak woods which have been analyzed.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Antimonous chloride as a Test for Cæsium.*—GODEFFROY has noticed that a solution of antimonous chloride in concentrated hydrochloric acid gives, in not too dilute solutions of cæsium, a white crystalline precipitate, not soluble in an excess of acid. The other alkali-metals are unaffected by this reagent. The precipitate, collected on a filter, washed with concentrated hydrochloric acid, and dissolved in the same acid, very dilute, yields on evaporation well formed, hard crystals, permanent in the air, and belonging to the hexagonal system. When obtained pure by repeated recrystallizations, analysis afforded chlorine 33·419, antimony 30·531 per cent, corresponding to the formula $SbCl_3CsCl$. It is decomposed by heat and also by treatment with water; though it is readily soluble without change in dilute acids. The author prefers this reaction to that obtained with stannic chloride by Sharples* and also by Stolba, since this produces precipitates with rubidium salts, difficultly soluble in hydrochloric acid, and if ammoniacal salts be present, throws down also the ammonium double salt; whereas both the ammonium and the rubidium double antimonous chlorides are easily soluble in concentrated hydrochloric acid.—*Ber. Berl. Chem. Ges.*, vii, 375, April, 1874.

G. F. B.

2. *On the Production of Black Phosphorus.*—RITTER finds that the black variety of phosphorus, first described by Thenard, and which is produced by the sudden cooling of melted phosphorus, can be uniformly obtained when the phosphorus contains arsenic. The property of becoming black may therefore be readily communicated to phosphorus by placing it for a short time in an arsenical solution, preferably acidified with hydrochloric acid. In thin layers, this form of phosphorus is translucent, and melts on heating to a colorless liquid, which on slow cooling becomes ordinary phosphorus. On treating the black variety with carbon disulphide, the black material is left as a residue, having the composition As_2P. In contact with air it becomes brown, and if preserved in water, the arsenic oxidizes and goes gradually into solution. The quantity of arsenic phosphide which is necessary to produce this blackening of phosphorus is very small, half of one per cent, and in some cases even less, being entirely sufficient. On evaporating the carbon disulphide in a current of carbonic gas, the phosphorus which is left is colorless and does not blacken on sudden cooling. Indeed, the same result may be produced mechanically: a tube constricted at a point a quarter of its length from below, is filled with the arsenical phosphorus and kept in fusion at a temperature of 50° for eight to ten hours. It is then very slowly cooled. On breaking the tube at the narrowed point,

* This Journal, II, xlvii, 178, 1869.

the phosphorus in the upper portion, in which the arsenic phosphide has collected, becomes black on sudden cooling, while that in the lower portion undergoes no such change. The author concludes therefore that black phosphorus is not an allotropic form of this substance, but that the result is due to a sort of liquation produced by the presence of an impurity. In the case of commercial phosphorus, this is generally arsenic; but other substances will effect the result, as is shown by Blondlot's black phosphorus produced by mercury. Ritter has obtained it with copper also.—*Bull. Soc. Ch.*, II, xxi, 151, Feb., 1874. G. F. B.

3. *Influence of the position of the Oxygen atoms in the Molecule upon the boiling point.*—From an extended comparison of metameric organic bodies containing oxygen, NAUMANN derives the following law relating to the influence of the position of the oxygen upon the boiling point: In metameric bodies of the same chemical character and of otherwise similar structure, the more the oxygen—similarly combined in the molecule—approaches the middle of the atomic chain, the lower is the boiling point. Of the numerous examples given, one from each class must suffice for illustration:

Normal Alcohols.

		Boiling point.
Normal primary butyl alcohol,	$CH_3.CH_2.CH_2.\underset{OH}{\underset{\vdots}{CH_2}}$	116°
" secondary " "	$CH_3.CH_2.\underset{OH}{\underset{\vdots}{CH}}.CH_3$	99°

Isoalcohols.

Fermentation amyl alcohol,	$\left.\begin{matrix}H_3C\\H_3C\end{matrix}\right\}CH.CH_2.\underset{OH}{\underset{\vdots}{CH_2}}$	128°–132°
Methylpseudopropylcarbinol,	$\left.\begin{matrix}H_3C\\H_3C\end{matrix}\right\}CH.\underset{OH}{\underset{\vdots}{CH}}.CH_3$	104°–108°
Dimethylethylcarbinol,	$\left.\begin{matrix}H_3C\\H_3C\end{matrix}\right\}\underset{OH}{\underset{\vdots}{C}}.CH_2.CH_3$	98·5°–102°

Mixed Normal Ethers.

Methyl-propyl ether,	$CH_3.CH_2.CH_2.O.CH_3$	49°–52°
Diethyl ether,	$CH_3.CH_2.O.CH_2.CH_3$	35·5°

Mixed Iso-ethers.

Methyl-isoamyl ether,	$\left.\begin{matrix}H_3C\\H_3C\end{matrix}\right\}CH.CH_2.CH_2.O.CH_3$	92°
Ethyl-isobutyl ether,	$\left.\begin{matrix}H_3C\\H_3C\end{matrix}\right\}CH.CH_2.O.CH_2.CH_3$	78°–80°

Compound Ethers.

Propyl acetate,	$CH_3.\underset{\underset{O}{\Vert}}{C}{-}{-}O{-}{-}CH_2.CH_2.CH_3$	101·98°
Ethyl propionate,	$CH_3.CH_2.\underset{\underset{O}{\Vert}}{C}{-}{-}O{-}{-}CH_2.CH_3$	98·8°

If we compare together methyl butyrate, $CH_3.CH_2.CH_2.\underset{\underset{O}{\Vert}}{C}{-}{-}O{-}{-}CH_3$, with propyl propionate $CH_3.CH_2.\underset{\underset{O}{\Vert}}{C}{-}{-}O{-}{-}CH_2.CH_2.CH_3$, the first of which boils at 102° the last at 122·44°, it would at first seem as if this law was contradicted; since the linking oxygen atom in the latter is exactly in the middle of the chain. But the explanation of this apparent anomaly is found in the fact, readily observed on comparing together butyl propionate $CH_3.CH_2.\underset{\underset{O}{\Vert}}{C}{-}{-}O{-}{-}CH_2.CH_2.CH_2CH_3$, and propyl butyrate, $CH_3.CH_2.CH_2.\underset{\underset{O}{\Vert}}{C}{-}{-}O{-}{-}CH_2.CH_2.CH_3$, boiling, the one at 145·99°, the other at 143·42°, that for an analogous position of the linking oxygen atom, the influence of the saturating or doubly combined oxygen atom is proportionately greater; so that in the former case moving the saturating oxygen atom from the center of the chain, more than counterbalances the approach toward it of the linking oxygen atom. This result the author explains by the hypothesis that when condensation from the gaseous to the liquid state takes place, similar parts of the various molecules approach more closely in proportion as the oxygen lies nearer the center of the chain.—*Ber. Berl. Chem. Ges.*, vii, 206, March, 1874. G. F. B.

4. *On the Vibration of Liquid Surfaces.*—BARTHÉLEMY has subjected to investigation the undulations which are produced upon liquid surfaces when these are thrown into vibration. Instead of producing the motion of the liquid by a sudden blow or an upward movement, as in the case of Faye's experiment, the author made use of a heavy tuning fork for this purpose, the vessel containing the liquid being in contact with it, either directly or through the intervention of the table on which both rested. The best results were obtained, however, when the vessel of liquid was placed upon the resonant case of the tuning fork itself. Similar results were also obtained upon the sounding board of a piano. In this way the surface of the liquid assumed a fixed condition of elevation and depression, the result of uniform vibration over its entire area. The phenomenon may be observed either directly by a small telescope, or better by projection upon a screen. For this purpose, a beam of sunlight is re-

flected upon the liquid surface obliquely; the reflected beam being rendered horizontal by a second mirror and thrown on to a screen, being first brought to a focus by a suitable lens. The image thus obtained is so steady that it may be photographed. In the case of transparent liquids, the incident beam must be much more oblique. Various attempts were made to fix these wave-surfaces, but without success. The best results were obtained by covering the surface of the vibrating mercury with fused stearin. The solidification of the latter afforded a cast of the wave-form. Fusible metal may be thrown into vibration, but its surface is distorted on cooling. The variously shaped vessels employed were either entirely of glass—in which case the walls should be equally thick in all directions—or were made with a wooden base with glass sides cemented together. Rectangular vessels give two sets of brilliant lines parallel to each side, formed by the ridges of the waves. Between these are less luminous lines produced by the hollows. Bright points are formed at the intersections of both. As the movement dies away, the lines parallel to the shorter sides disappear first, leaving those parallel to the longer; though sometimes components of both are left forming zigzags diagonally across the surface. From his experiments Barthélemy deduces the two following laws: 1st, the breadth of the undulations is inversely as the number of vibrations; and 2d, the distance between two lines produced by the same fork is independent of the density of the liquid. The figures given by circular masses of liquid consist of equidistant circular lines intersected by radii equally equidistant; thus giving trapezoidal forms with curvilinear bases. If the fork touches the vessel, a cross of no vibration appears corresponding to the nodal lines of this vessel. As the vibration ceases, two opposite sectors disappear and the two alternate ones remain. By placing sand on the surface of the mercury and then covering it with water, circular lines are formed and also the cross of no vibration; the sand gathering in heaps at the vibrating parts. Triangular vessels give lines perpendicular to the sides, forming brilliant hexagons, the centers of which are the angles of fainter hexagons, having the radii of the first set for sides. As the motion lessens, only one set of lines persists and the surface is covered with rectilinear waves perpendicular to one of the bases. Elliptical vessels give figures of exceeding beauty, the lines having reference to the two axes of the ellipse. The author calls attention to the general character of these wave-surfaces. In the basin of a fountain, in the waves of the sea, these forms are recognized. Even in the sand on the sea bottom they can be traced. Certain lines thus made gave on measurement 2·6 vibrations per second. They may be seen 100 meters from the beach and at a depth of eight or ten meters. So, out of the water, the sand on the beach was found to have taken these forms; thus suggesting that the air itself was capable of similar vibration. So also clouds are arranged often in parallel bands, being then considered a precursor of fine weather. Even in geology, the author thinks certain regular and equidistant foldings of stratified rocks evidence of analogous vibrations. The ventral segments of a liquid vein, M. Barthélemy thinks, are produced by the vibration of the liquid mass upon which it falls reacting upon it. And he makes an ingenious application of these facts to account for the phenomena of stratification produced by electric discharges in rarefied media.—*Ann. Chim. Phys.*, V, i, 100, Jan., 1874. G. F. B.

5. *Expansion of Gases.*—PH. JOLLY has recently conducted a series of experiments on the expansion of gases, and a new form of air-thermometer. His apparatus consists of a bulb tube containing the gas to be studied, connected by a long rubber tube, containing mercury, with an open cylindrical manometer tube. By varying the height of the latter the pressure may be altered at will. The volume of the gas is always rendered precisely the same by bringing the mercury just in contact with a glass point inside the bulb tube. The observation therefore consists in measuring the pressure at various temperatures. The coefficient of expansion of various gases was thus determined with the following results. The numbers are multiplied by 10^6 or one million, to render a comparison more convenient. The coefficient for air was found, from 20 measurements, to be 3669·6, while Rudberg found it 3645·7, Regnault 3665, and Magnus 3667·8. Hydrogen gave a result 3656·2, nitrogen 3667·7, oxygen 3674·3, carbonic acid 3706·7. The same instrument is also readily employed as an air-thermometer.—*Poggendorff's Jubelband*, p. 82. E. C. P.

6. *Refraction and Dispersion of Gases.*—MASCART has employed for this purpose a spectroscope in which the collimator is placed at a considerable distance from the prism. The parallel beam emerging from the collimator is divided into two by a double plate of the form proposed by Fizeau, and the two equal portions are thus separated several millimeters. They next traverse tubes to contain the gas, closed with plates of glass and are then brought together by a second double plate turned in the opposite direction from the first, and are finally refracted by the prisms.

If we cause a difference in path of the rays either by varying the pressure of the gas in one of the tubes, or by turning the double plates, a series of dark lines are produced in the spectrum known as Talbot's bands. In any case, calling D the difference in path or retardation, F the number of a particular band and λ its wave-length, we have $D=F\lambda$. Calling n the index of refraction and H the pressure to which the gas is subjected, it is found that we may express the value of n by the equation $n-1=a\,(1+\frac{1}{2}\,B\,H)$, in which a and B are constants. In the same way Regnault's results for pressures under 8 atmospheres show that $\frac{d}{H}=A'(1+B'H)$, so that if the excess of refraction $n-1$ is proportional to the density d of the gas, the two coefficients $\frac{1}{2}\,B$ and B' should be equal.

In the following table are given for various gases the values of B' as determined by Regnault and $\frac{1}{2}\,B$ measured as described above. We may remark that the refraction and compressibility vary alike, in one direction for hydrogen and in the opposite way for all the other gases. That they are of the same order of magnitude, except for binoxide of nitrogen and carbonic oxide, while in no cases are they exactly equal;

Gas.	$B' \times 10^5$	$\frac{1}{2}B \times 10^5$	$\beta \times 10^5$	$10^3(n-1)$	$C \times 10^4$
Hydrogen	− 57	−87	381	·1388	44
Air	+107	+72	383	·2923	58
Nitrogen	68	85	382	·2972	69
Protoxide nitrogen	754	880	388	·5084	127
Binoxide nitrogen	225	70	367	·2967	
Carbonic oxide	435	89	367	·3336	75
Carbonic acid	901	720	406	·4494	52
Sulphurous acid	3220	2500	471	·6820	
Cyanogen	3220	2700		·8202	100

This difference may be in part due to the difficulty of their determination, to differences of temperature, and to want of exactness of the formulas employed. Hence we may say that at a constant temperature the excess of refraction $n-1$ of a gas is nearly proportional to the density.

The same law does not hold as we change the temperature; if f is the number of bands which pass when the pressure varies from one value to another, $f(1+at)$, instead of being constant, continually diminishes as the temperature rises, so that the usual coefficient α must be replaced by a larger one β, whose value multiplied by 100,000 is given for temperatures below 40° in column four of the above table. In the case of carbonic acid and binoxide of nitrogen β has the same value as α.

To find the absolute index of refraction it is sufficient to measure the length of the tube and to know the value of the wave-length λ. With the soda-flame the index was found to be what is given in column five of the table, that is the index for air $n=1{\cdot}0002923$, the temperature being 0° and the pressure 760 mms.

The same apparatus was employed to measure the dispersion of different gases. The slit of the collimator is illuminated at the same time by the calcium or other white light and by the sparks of an induction coil between metallic conductors. In the spectrum may then be observed at the same time the bright lines of the metals and the bands of Talbot. Making the experiment at different pressures, affords a means of determining the dispersion, or of measuring C in the formula of Cauchy $n-1=A\left(1+\frac{C}{\lambda^2}\right)$. These values multiplied by 10,000 are given in column six of the table.

To show more exactly the order of magnitude of the dispersion of gases compared with that of other well known bodies, the value of the dispersive power $\frac{n'-n}{n-1}$ has been computed between the rays B and H of the solar spectrum. For air the result is ·024, for the ordinary ray in quartz ·032, for water ·040, for crown glass ·038, for protoxide of nitrogen ·053, for heavy flint glass ·69.—*Comptes Rendus*, lxxviii, 617, 679. E. C. P.

7. *Refraction of compressed water.*—MASCART has combined the apparatus described above, with that employed by Jamin, to study interference in compressed water. The two tubes were about two meters in length and the pressure in one was kept constant while it could be varied at will in the other. A change of pressure of one meter caused about 70 bands to pass any given point, so that a variation of one or two mms. was perceptible.

First, he proved that at a constant temperature the ratio of the number of bands passed, to the change of pressure is not proportional to the pressure but increases slightly with it. At 15° for a change of one meter 67·70 passed when the mean pressure was one meter, and 68·52 when it was 3·30 meters. It seems to result from this that the compressibility of water varies more rapidly than the pressure, as has already been observed for other liquids. For a temperature of 5·5° the number of bands was 71·85, corresponding to a change much greater than that resulting from the experiments of M. Grassi. The same effect was obtained whether the pressure was transmitted by a column of water or a mass of air. Assuming the laws of the refractive powers, or that n^2-1 is proportional to the density, the compressibility $\mu = \cdot 0000518$. Assuming that $n-1$ is proportional to the density gives $\mu' = \cdot 0000453$. The first result is very nearly that obtained by Jamin, but Grassi, by direct experiment, found $\mu = \cdot 0000471$, so that neither hypothesis seems to be exact.

The extreme delicacy of this method renders it possible to measure the disengagement of heat produced by the compression of water, or rather the lowering of temperature when the pressure is suddenly removed. One of the tubes being at a great pressure, a stopcock was suddenly opened which allowed a few drops to escape and instantly reduced the pressure to that of the atmosphere. During this time a great number of bands passed, too rapidly to be counted, but this effect ceased suddenly and the bands appeared immovable. On continuing to observe them for some time, they were seen to continue to move slowly in the same direction, owing to the gradual return of the liquid to the temperature of the surrounding medium. At 16° a fall of pressure of 4·38 meters produced in this way a motion of 1·9 bands; hence the index of refraction had diminished ·00000056. From the experiments of Gladstone and Dale it follows that this corresponds to a change in temperature of ·00110°. A computation gives a result ·00109°. The closeness of this agreement is however accidental, as the position of the bands could only be determined to one-tenth.—*Comptes Rendus*, lxxviii, 801. E. C. P.

8. *Maximum of density of water.*—Prof. MACH has determined the temperature at which water reaches its maximum of density to be +3·945°. The method employed was that of Rumford, substituting for thermometers thermo-piles which give more promptly the temperature of the surrounding medium.—*Proc. Acad. Vienna, Les Mondes*, 506. E. C. P.

9. *The Gaseous, Liquid and Solid States of Water-substance.*—Prof. J. THOMSON recently communicated to the Royal Society a

paper on the pressure of aqueous vapor from ice and water. Taking into consideration the three states, gaseous, liquid and solid, when any two are present together the pressure and temperature are dependent each on the other, so that when one is given the other is fixed. Representing the pressures by ordinates and temperatures by abscissas, we obtain three curves, which must all cross each other in one point, the freezing point in vacuo, or rather in the presence of no gas but its own vapor. It has commonly been assumed that the curves were tangent to each other at this point, so that the rate of increase of the pressure was the same for ice as for water. By the principles of thermodynamics, however, Sir Wm. Thomson proved that these curves, instead of being tangent, were inclined at an angle forming a salient point directed upward, the rate of increase of the pressure suddenly diminishing when the ice melted and then slowly increasing, the ratio of the inclinations in the two cases being 1·13. The next point was to discuss the observations of Regnault, which was done, employing both his engraved curve and the empirical formulæ, and these also it is claimed render probable the presence of the salient point.—*Nature*, 392.

E. C. P.

II. Geology and Natural History.

1. *Glacial phenomena in Nicaragua.*—Mr. Thomas Belt, in his "Naturalist in Nicaragua," published in London early the present year, describes, as follows, Drift deposits in the valley of the Depilto, one of the head streams of a river (Rio Wanks or the Segovian) that rises among the highest mountains of northern Nicaragua, and reaches the Atlantic near Cape Gracias a Dios.

"Going down the valley of the Depilto the massive beds of quartz and gneiss are soon succeeded by overlying, highly inclined and contorted schists, and, as far as where the road from Ocotal to Totagalpa crosses the river, the exposures of bed rock were invariably these contorted schists, with many small veins of quartz running between the laminæ of the rock. On the banks of the river, from about a mile below Depilto, unstratified beds of gravel are exposed in numerous natural sections. These beds deepen as the river is descended, until at Ocotal they reach a thickness of between two and three hundred feet, and the undulating plain on which Ocotal is built is seen in sections near the river to be composed entirely of them. These unstratified deposits consist mostly of quartz sand, with numerous angular and subangular blocks of quartz and talcose schist. Many of the bowlders are very large, and in some parts great numbers have been accumulated in the bed of the river by the washing away of the smaller stones and sand. Some of these huge boulders were fifteen feet across, the largest of them lying in the bed of the river two miles below Depilto. Most of them were of the Depilto quartz rock and gneiss, and I saw many in the unstratified gravel near Ocotal fully eight miles from their parent rock. Near Ocotal this unstratified formation is nearly level, excepting where worn into deep gulches by the existing streams. The river has cut through to a depth of over two hundred feet, and there are long precipices of it on both sides, similar to those near streams in the north of England that cut through thick beds of bowlder clay. The evidences of glacial action between Depilto and Ocotal were, with one exception, as clear as in any Welsh or Highland valley. There were the same rounded and smoothed masses of rock, the same moraine-like accumulations of unstratified sand and gravel, the same transported bowlders that could be traced to parent rocks several miles distant."

* * * "The transported boulders, near Ocotal, are about three thousand feet above the sea, those near Libertad about two thousand feet"

Mr. Belt infers, from the facts, that the ice of the Glacial era stretched on uninterruptedly from the northern regions of North America through Central America, and probably over South America. But observers have shown that the glacial phenomena occurring on a grand scale about the higher mountains of California and of the summit region of the Rocky Mountains, within the United States, are those of *local* glaciers, and that there is there no *northern* drift. This being so, it is certain that the facts described by Mr. Bent indicate the existence only of *local* glaciers —those of the mountains of northern Nicaragua. They are still of very great interest, as they give a much more southern limit in North America to the local glaciers of the Glacial era than had been before suspected. J. D. D.

2. *Geological Structure of the Alps.*—In the Geneva Archives des Sciences (Bibliothèque Universelle) for February, M. Charles Lory explains at length his theory in regard to the structure of the central mass of the Alps, which he had before announced in his *Description géologique de Dauphiné*, being led to this exposition of his views because of his having been criticized by Studer.

The great facts in the Alps to be explained are: (1) the vertical, or nearly vertical, divisional planes of the gneiss and granite, with the so-called *fan-structure*; (2) the relative position of the secondary deposits (Triassic or Jurassic) lying unconformably upon the crystalline rocks, more generally horizontal, as in the Chamouni region; and (3) the wedge-like inclosures of these strata in the gneiss so strikingly exhibited in the Bernese Oberland.

According to Studer, the gneiss and granite are properly massive, destitute of stratification, the vertical jointings having been formed subsequent to the Jurassic period, and in some cases to the Eocene. Lory, on the other hand adopts the view of De Saussure that the crystalline rocks are really metamorphic, and that there is a true stratification of sedimentary origin, although it is not to be understood that the divisional planes are all of this nature, the structure being often equivalent to that observed in the porphyritic and trappean rocks. The gneiss shows the stratification distinctly; the granite much less so—though it often passes into the former by insensible gradations, and thus evinces a common origin with the gneiss; at the same time, true massive, igneous granites are also to be found.

That the stratification of the gneiss is of very ancient origin is clearly seen in the fact that bowlders of it, with the same structure, are often met with in the conglomerates of the Carboniferous, as well as in the later formations. Further, the position of the anthracite (Carboniferous) beds conformable to the crystalline rocks demonstrates the reality of the stratification of the gneiss.

The course of events, according to M. Lory, was this: After the deposition of the Carboniferous, and before that of the Trias, the whole complex system of rocks was upturned and metamorphosed, the strata being thrown into a generally vertical position; then followed the scanty deposits of the Triassic and Jurassic, and then further mountain-making movements. The older rocks at this time were rigid and unyielding, and could accommodate themselves to the pressure only by fracture and faulting, the movements taking place in the planes of stratification, or along horizontal planes. The secondary strata, on the other hand, were comparatively soft and pliable, and yielded readily to the acting force, bending and folding according to the movements of the solid rock beneath, and mostly without fracture. Thus, while the crystalline rocks were broken and faulted on a grand scale, the more recent strata were sometimes left horizontal, sometimes pressed in between the others so as to seem to be conformable, or shoved over and folded upon themselves in the most intricate manner.

M. Lory describes the relations of the rocks of the Petite Gorge of Mt. Salève as an illustration, on a small scale, of these results produced in the adaptation of an upper flexible formation to the new forms of a rigid one below, which has been dislocated by faults or fracture. Besides applying this principle to the portions of Switzerland specially studied by himself, he says that it will also suffice to explain the extreme irregularities observed in the Bernese Oberland.

On the Italian side of the Alps, zones of the crystalline rocks are found which are still nearly horizontal, and which consequently have suffered the same change of position as the secondary strata by which they are covered. At these localities, for example, at Susa, or Mont Cenis, we find, as we should expect, the same regularity of arch that exists in the Jura Mountains.

The so-called *fan-structure* of Mont Blanc and the St. Gotthard is connected with the original stratification, it having been produced by the enormous lateral pressure, which was greatest below, and hence caused there a convergence of the divisional planes, while above, where the compression was less great, there was a divergence. The effect produced then may well be compared, as the writer suggests, to a sheaf of grain tightly knotted at the center. E. S. D.

3. ***Bulletin of the United States Geological and Geographical Survey of the Territories.*** Department of the Interior.—Bulletin

No. 2, announced on page 236, has been issued more than a month. After papers by Cope, referred to in that notice, there follows one by L. Lesquereux on *the general characters and relations of the flora of the Dakota Group of the Cretaceous.* The genera represented are *Pterophyllum* (Cycad) doubtful; *Liquidambar, Populus, Salix, Fagus, Betula, Myrica, Quercus, Ficus, Platanus, Laurus, Sassafras, Cinnamomum, Diospyros, Laurus, Aralia, Hedera, Magnolia, Liriodendron, Menispermum, Paliurus, Rhamnus, Juglans* or *Rhus, Prunus,* nearly all of which now exist and characterize the North American flora. "Indeed, all the essential arborescent types were there except those which are marked by serrate or doubly serrate leaves, as *Tilia, Æsculus,* the serrate *Rosaceæ, Hamamelis, Fraxinus,* the *Urticinæ, Planera, Ulmus, Celtis, Morus,* and the *serrate Betula, Alnus, Ostrya, Carpinus, Corylus, Carya,* etc." The Dakota species are marked by the leaves being entire and coriaceous, excepting a "peculiar short denticulation with outside turned teeth, as in *Populites Haydenii, P. flabellata, Platanus Newberryi, Quercus Mudgii.* The flora is remarkable for its distinctness from that of the Lignitic beds, and also for the absence of any European species of the same age.

The closing article is an important one by James T. Gardner on the Rocky Mountain ranges in Colorado.

4. *The Geological and Natural History Survey of Minnesota. The Second Annual Report,* for the year 1873; by N. H. Winchell, State Geologist, and S. F. Peckham, State Chemist.—This Report treats at length of the distribution of peat in Minnesota, and of the modes of working it, and also gives many facts on the Cretaceous and other geological formations of the State. It closes with a chapter on the Economical geology of the Minnesota Valley, in which, among the various facts, it is stated that the Lignitic beds of the Cretaceous are likely to afford valuable coal mines.

5. *Skeleton of a Whale in the Quaternary of New Brunswick;* by D. Honeyman. (Communicated.)—A skeleton of *Beluga vermontana?*, found in clay of the Champlain Period, at Jacquet River, Dalhousie, New Brunswick, has been presented to the Provincial Museum, Halifax, N. S., by Henry Townsend, Esq. It was found in a cutting of the International Railway, at a depth of twelve feet six inches, at a distance of 400 yards from the sea and twenty-five feet above the sea level. The clay attached to the vertebræ contains numerous fragments of *Balanus.* Dr. Galpin will describe the fossil in a paper to be read before the Institute of Natural Science.

6. *Note on Prof. Heer's new work on the Fossil Flora of the Arctic;* by L. Lesquereux. (Communicated.)—I have received from Prof. Heer a most interesting pamphlet on the Swedish expeditions for the explorations of the high north. In this paper the celebrated Professor gives first an abridged narration of the progress and casualties of these explorations, and then sums up in a masterly manner the results obtained for vegetable paleontology, as far at least as they were recognized from a preliminary examination of an immense amount of material collected and sent to him.

From the Lower Cretaceous of the northern side of Noursoak Peninsula, and in a bed of black shale overlying the gneiss which forms the essential bulk of the land, he found a flora of sixty-eight species, of which seventeen belong to Conifers, nine to Cycadeæ, thirty-eight to Ferns, three to Equisetaceæ, and only one to the Dicotyledons, this a peculiar kind of Poplar. On the south side of the same peninsula near Alanekerduk, on another formation of grayish black shale, Professor Nordenskiöld, Director of the expedition, discovered a quantity of well preserved vegetable remains at a higher level or in the Upper Cretaceous. The specimens represent sixty-two species, viz: ten Conifers, among them a *Salisburia*, found with leaves and fruits, two Cycadeæ, thirteen species of Ferns, and thirty-four dicotyledonous species, distributed in sixteen families and eighteen genera. Among these he mentions leaves of *Ficus*, *Sassafras*, *Diospyros*, *Magnolia*, *Myrtus*, *Leguminosæ*, and remarks that some of the species are known already from the Quadersandstein of Saxony, Bohemia, Moletin (Moravia).

Only five of these species—three Ferns and two Conifers—are identical with those of the first locality or the Lower Cretaceous. Eight hundred feet above this formation, they still found strata of clay and sandstone filled with a prodigious quantity of remains of fossil plants, which, according to Heer, represent a flora of the lowest Miocene; among them he identifies one hundred and thirty-three species, fifty of which are also found in the Miocene of Europe. This flora is totally different from that of the Cretaceous of the same country, no species being identical. This Tertiary formation is covered, like the whole land, by immense deposits of lava.

7. *Eozoon Canadense, the supposed fossil of the Archæan.*—In the April number of the Annals and Magazine of Natural History, a reply to the article by Mr. Carter, from which, on page 437 of this volume, a few paragraphs are cited, is published by Dr. Carpenter, who states that his specimens, which he would be pleased to show to all interested, fully sustain his view. In the May number, Mr. Carter has a rejoinder, repeating his conclusion, based on his extensive knowledge of living Rhizopods. The latter number contains also a paper by Messrs. King and Rowney, repeating their arguments against the animality of the Eozoon.

8. *Manuel de Minéralogie;* par A. Des Cloizeaux, Membre de l'Institut de France, etc. Tome second. Premier Fasicule. 208 pp. 8vo. Paris, 1874. (Dunod.)—Des Cloizeaux's Mineralogy is made up largely of the results of extended personal investigations, especially in its crystallography, and in the accounts of the optical characters of minerals. It is partly for this reason that twelve years have elapsed since the publication of the first volume of his very valuable work. That volume was occupied with the Silicates. This first part of the second volume, after some additional notes on the Silicates, goes on with the species in the following order: (1) those containing Boron; (2) Carbon, the coals, resins, etc., included, and then the oxalates and carbonates; (3)

TITANIUM, which group is not completed. This new part contains plates LIII to LXVIII inclusive.

9. *System of Mineralogy by James D. Dana.*—The 5th "Subedition" of this work was issued by Wiley & Son, in April, 1874. Each "subedition" (or issue from the stereotype plates) embodies corrections of all errors discovered in the work up to its date of publication. The last, in addition to a number of such emendations, also has the Appendix, by Prof. Brush, bound up with the main volume.

10. *A Revision of the North American Chenopodiaceæ;* by SERENO WATSON. Extracted from Proceedings of the American Academy of Arts and Sciences, vol. ix, pp. 82–126.—The *Chenopodiaceæ*, of comparatively small extent and interest in the Eastern Atlantic United States, increase in number and variety westward, especially in the dry interior portion of the continent, where they form as conspicuous and characteristic a feature of the flora as they do in the corresponding region of Asia, although they are not so very numerous in species. Our lamented chief, Dr. Torrey, made them a favorite study, and described or made notes upon many of our species, but never found time to work them all up systematically. Mr. Watson has lately undertaken this, with much spirit and assiduity; and we have the result in this most conscientious and painstaking monograph, upon the same model as those upon *Lupinus*, *Œnothera*, &c. The species are neatly defined, carefully arranged, and very considerably increased in number. It here appears that we have 17 genera, of which two (*Sarcobatus* and *Grayia*, the Grease-woods of the interior desert-region) are the most peculiar, and 82 species. One of them, *Roubieva*, is not indigenous, but a chance introduction from South America. Of the 16 proper genera, all with indigenous representatives, seven, or nearly half, are common to the Old World, but two in Asia only. Of the 82 species, 8 are introduced (mostly species of *Chenopodium* and *Blitum*); of the 74 indigenous species only 9 are common to the Old World. The natural comparison is with the Flora Rossica, in which 39 genera are admitted and 184 species Even if we exclude European Russia, there is still a preponderance of *Chenopodiaceæ* in the Old World, especially in Asia. Only two of these (*Teloxys* and *Monolepis*) are peculiar to Asia and America, and (as in the analogous cases) are of limited and closely allied species. Our peculiar genera are *Sarcobatus* (here incorporated without question, or reference to Moquin's exclusion of it), *Aphanisma*, *Cycloloma*, and *Grayia* (with structure newly and better described), each of single species; all but the first with annular embryo. Of *Salsoleæ*, with conical-spiral embryo, which largely preponderate in Asia, we have only a single and maritime *Salsola*, of world-wide distribution, while the Flora Rossica has 24, and ten genera besides. Of the flat-spiral group, besides *Sarcobatus*, we have only *Suæda*, which Mr. Watson has brought up to seven species; while the Flora Rossica counts about thrice the number of genera and species. Our strength is in *Atriplex*, in-

cluding *Obione.* The Flora Rossica describes 20 species. But Mr. Watson, as the result of the first comprehensive study of the materials, has brought the number of our species up to 40. That is, if we exclude the introduced weeds, more than half our *Chenopodiaceæ* belong to this genus. Copies of this monograph can be had from the American Naturalist Literary Agency at Salem.

A. G.

11. *Sarracenia variolaris.*—The suggestion in a recent number of this Journal (April, 1874, p. 442), that the pitchers of this species and the way in which insects are caught in them should be carefully scrutinized by those who have this plant within their reach, has already begun to be acted upon. Dr. J. F. Mellichamp, of Bluffton, South Carolina, an excellent observer, has already made some very interesting observations upon this species, which abounds in his neighborhood, and has there, even in the first days of May, developed some of its pitchers. His observations and experiments will no doubt be continued and extended. But it may be well to record at once some results to which his first observations point, as communicated in a private letter,—which are substantially as follows.

The efficiency of the tubular leaves of *S. variolaris* and the presence of the sugary secretion within the rim, as stated by Dr. Macbride, are fully confirmed. The sugary secretion, however, seldom appears until the leaf is pretty well grown. This is also the case in *S. flava.* It bedews the throat all the way round the rim, and extends downward a quarter of an inch or more, sometimes three-quarters of an inch. Dr. Mellichamp also informs us —and this is his most curious discovery—that this sweet secretion is continued externally in a line along the edge of the wing of the pitchers down to the petiole or to the ground, forming a honeyed trail or pathway up which some insects, and especially ants, travel to the more copious feeding-ground above, whence they are precipitated into the well beneath. Ants, as we learn from other sources also, are largely accumulated in these pitchers. As to the supposed intoxicating qualities of this secretion, Dr. Mellichamp was unable to find any evidence of it. On cutting off the summit of the pitchers and exposing them freely to flies in his house, he found that the insects which came to them, and fed upon the sweet matter with avidity, flew away after sipping their fill, to all appearance unharmed. On the other hand, he thinks that the watery liquid in which the insects are drowned and macerated possesses anæsthetic properties; that house-flies, after brief immersion in it, and when permitted to walk about in a thin layer of it, "were invariably killed—as at first supposed—or at any rate stupified or paralyzed in from half a minute to three or five minutes," but most of them would revive very gradually in the course of an hour or so. It is important to repeat and scrutinize these experiments. A. G.

12. **Joshua Hoopes**, the last survivor of the old school of the Botanists of Chester County, Penn., of which Darlington was

the chief, and the Flora Cestrica the memorial, died on the 11th of May, at the age of 86 years.

13. *Tube-building Amphipoda;* by S. I. Smith.—In examining recently an alcoholic specimen of a species of *Xenoclea*, I noticed a peculiar opaque glandular structure filling a large portion of the third and fourth pairs of thoracic legs, which in most, if not all, the non-tube-building Amphipoda are wholly occupied by muscles. A further examination shows that the terminal segment (dactylus) in these legs is not acute and claw-like, but truncated at the tip and apparently tubular. In this species, a large cylindrical portion of the gland lies along each side of the long basal segment, and these two portions uniting at the distal end pass through the ischial and along the posterior side of the meral and carpal segments and doubtless connect with the tubular dactylus. There can be no doubt that these are the glands which secrete the cement with which the tubes are built, and that these two pairs of legs are specialized for that purpose.

A hasty examination revealed a similar structure of the corresponding legs in *Amphithoe maculata*, *Ptilocheirus pinguis*, *Cerapus rubricornis*, *Byblis Gaimardi*, and a species of *Ampelisca*. In all these except the last two a very large proportion of the gland is in the basal segment. In the *Amphithoe* this segment is thickened and the gland is in the middle. In the *Cerapus* it is very broad and almost entirely filled by the gland, with only very slender muscles through the middle, and the orifice in the dactylus is not at the very tip but sub-terminal on the posterior side. In the *Ptilocheirus* the gland forms three longitudinal masses in the basal segment and is also largely developed in the meral and carpal segments. The dactylus is long and slender and the orifice sub-terminal. In *Ampelisca* and *Byblis* (which, like *Haploöps*, are tube-building genera) the meral segments of the specialized legs are nearly as large as the basal and contain a proportionally large part of the gland. In these genera the remarkable elongation of the two distal segments in the third and fourth pairs of legs is perhaps a special adaptation to enable them to reach back over the deep epimera.

The examination of fresh specimens will doubtless show these structures much more fully.

14. *On a New Genus of Asellidæ;* by Oscar Harger.—The presence of mandibular palpi has been hitherto regarded as a character of the family of *Asellidæ*, and is thus given by Dana (U. S. Exploring Expedition, Crustacea, p. 714), and by Bate and Westwood, in their late work on British Sessile-eyed Crustacea, vol. ii, p. 313. This organ is present and well developed in *Jæra copiosa*, *Asellodes alta*, and *Limnoria lignorum*, marine species of this family found on the coast of New England. It has been carefully figured by G. O. Sars (Hist. Nat. des Crustacés d'eau Douce de Norvège, 1e livr. pl. VIII) for *Asellus aquaticus* and occurs in *A. communis* Say as well developed as in the European species, but in *A. tenax* Smith, from Lake Superior, it is wanting. This

species seems to be in all other respects closely related to the genus *Asellus*, differing from other species of that genus by characters of specific value only. The most noticeable of these differences are the following: the antennulæ have the third segment of the peduncle small, short and similar to those of the flagellum; the ocelli are numerous as in *A. communis;* the appendages of the first abdominal segment in the females are subquadrant-shaped, meeting each other along the median line, much as in *A. communis*, instead of subcircular and overlapping as in *A. aquaticus.* The caudal stylets resemble those of *A. aquaticus*, as do also the feet and the mouth parts, except in the absence of the mandibular palpi, and on this character I propose for the species the new generic name of *Asellopsis.—Communicated by the Author.*

15. *Floridan Bryozoa, collected by Count L. F. de Pourtales*, described by F. A. SMITT. Part I, 20 pp. 4to, with 5 plates. Part II, 84 pp. 4to, with 13 plates. Transactions of the Royal Swedish Academy, Stockholm, 1873.—Mr. Smitt has no superior in the department of the Bryozoa. He describes with fullness a large number of species, and presents enlarged figures of them in the plates. After giving a table of the depths at which the species occur in Florida seas, and their distribution also in other seas, he observes that the deeper waters contain either very old species, or those having a wide geographical distribution and especially Arctic or Antarctic relations. A few of these Bryozoa are identical with Cretaceous species and a larger number with Tertiary.

16. *Report upon the Invertebrate Animals of Vineyard Sound and adjacent waters, with an account of the Physical Features of the region;* by A. E. VERRILL and S. I. SMITH. 8vo, 478 pp. and 38 plates.—This work is extracted from the report of the U. S. Fish Commission, noticed beyond, with separate paging. It is accompanied by a special index and table of contents, and includes the following papers: A, Habits and distribution of the invertebrate animals of southern New England and New York, with special reference to their stations, mode of occurrence, as depending upon the temperature and composition of the water, character of the bottoms and shores, etc.; B, Food of fishes, or lists of species found in the stomachs of various fishes; C, Habits and metamorphoses of the lobster and other crustaceans (by S. I. Smith); D, Systematic catalogue of the invertebrates of southern New England and adjacent waters, with their synonomy, geographical and geological distribution, and descriptions of numerous new species. The total number of species enumerated is about 725, (not including the free Entomostraca, Infusoria and Foraminifera). Detailed accounts are given of those species which are directly injurious or beneficial to man, such as the oyster, clams, *Teredos* or "ship-worms," "drills," star-fishes, lobsters, crabs, etc. The 38 plates include about 300 figures, illustrating many of the more important species belonging to nearly every class. This work will be indispensable to every person engaged in studying or collecting the marine animals of our coast, and will afford great assistance to the numerous students who visit the sea-shore in summer.

17. *Field Ornithology, comprising a manual for procuring, preparing, and preserving birds, and a check-list of North American birds;* by Dr. ELLIOTT COUES, U. S. A. Salem, Mass., Naturalists' Agency, 1874.—The scope of this work is clearly indicated by the title. It contains a large amount of useful information for those engaged in the study of ornithology. The directions are very full and clearly expressed, and the advice in regard to a great variety of matters connected with the subject of bird-collecting is sensible, and will prove of great value to those beginning the study. The reputation of the author as one of our most accomplished ornithologists is a sufficient guaranty for the excellence and reliability of the work. The check-list of birds is brought down to the latest discoveries in American ornithology. V.

III. ASTRONOMY.

1. *New Comets.*—Two new comets have been discovered this year, besides that by Winnecke, Feb. 20th (this Journal, p. 446), viz: one by Winnecke, April 11th, and one by Coggia, April 17th.

2. *Inclinations of the orbits of periodic comets.*—In connection with the important observations by Prof. Wright, in the last number of this Journal, upon the polarization of the Zodiacal Light, and his deductions therefrom, the question naturally arises whether there is any constant action of the perturbing forces of the planets tending to draw the meteoroids into orbits of small inclination to the plane of the solar system. The fact that the orbits of most of the periodic comets have a small inclination (counting from 0° to 180°) is sufficiently striking to stimulate inquiry in this direction. The additional fact that several of these orbits are now inclined at a smaller angle to the ecliptic than when first discovered, and that none have essentially larger inclinations, also suggests the possibility of some such law of action. I have not been able, however, in a partial examination of the subject, to detect in the perturbing function, any evidence of such constant forces. H. A. N.

3. *Cordoba Observatory.*—We have received a letter from Dr. Sellack of Cordoba, replying to Dr. B. A. Gould's letter, published in this Journal, vol. vi, p. 399; it is endorsed by five of the professors of the University. We do not publish it, since, whatever may be said of some points connected with the subject, Dr. Sellack violated the law and usage of all observatories in publishing results obtained while under the employ of the Observatory, without the knowledge or approval of its Director.—EDS.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *National Academy of Sciences.*—The following is a list of the papers presented to the Academy at its session in April, 1874.

On the classification of the Rynchophorous series of Coleoptera; J. L. LeConte.

Results of a series of experiments on the sets, or residual deflections of pine sticks after having been subjected to a transverse stress; W. A. Norton.

Combinations of Mechanism imitating mental processes; Fairman Rogers.

On the Tides of Tahiti; Wm. Ferrell.

On the Laws of Cyclones; Wm. Ferrell.

On the pretended localization of the mental and the sensorial faculties of the brain; C. E. Brown-Sequard.

Biographical Memoir of Henry James Clark; A. S. Packard, Jr.

Suggestions as to the functions of Spiral Scalæ of the Cochlea, leading to an hypothesis of the mechanism of audition; A. M. Mayer.

The law of the duration of the residual sonorous sensation; A. M. Mayer.

Experiments on the reflection of Sound from flames and heated gases; A. M. Mayer.

The progress made in the Survey of the Colorado River of the west and its tributaries, by parties under the direction of the Secretary of the Smithsonian Institution; J. W. Powell.

An outline of the history and operations of the U. S. Geological Survey of the Territories, with some account of its results; F. V. Hayden.

The geographical distribution of the Lignitic group of the northwest, with some remarks in regard to its age; F. V. Hayden.

Mineralogical notes; B. Silliman.

The history of Smith Sound in a geographical and geological point of view, and some other general results of the Polaris Expedition; E. Bessels.

On metamerism in inorganic chemistry; Wolcott Gibbs.

On the Polarization of the Zodiacal Light; A. W. Wright.

Account of the proceedings of the Commission for observing the Transit of Venus; A. Newcomb.

On some points in Mallet's theory of Vulcanicity; E. W. Hilgard.

Report on the Great Telescope of the U. S. N. Observatory; S. Newcomb.

Some results of an examination of the U. S. Weather Maps for the years 1872 and '73; E. Loomis.

On a small correction of the Velocity of Light, as deduced from experiments; S. Alexander.

On certain phenomena sometimes presented by three of the Satellites of Jupiter; S. Alexander.

On the Zodiacal Light; S. Alexander.

Biographical Memoir of James H. Coffin; A. Guyot.

On the so-called land-plants of the Lower Silurian of Ohio; J. S. Newberry.

A criticism on the contractional hypothesis of the earth's surface changes; C. Dutton.

A new set of Bernouilli's Numbers; James D. Warner.

2. *American Association for the Advancement of Science.*—The Twenty-third meeting of the Association will be held at Hartford, Connecticut, commencing at 10 o'clock, A. M., on Wednesday, the 12th day of August, 1874. Dr. L. LeConte is the President of the year, Prof. C. S. Lyman, Vice President, Mr. F. W. Putnam of Salem, Mass., Permanent Secretary. The headquarters of the Association will be at the State House, where members will report immediately on arrival.

At an early date, the Local Committee will issue their circular to members of the Association, giving details relating to the arrangements made for the accommodation of members while in Hartford, and such other information as may be of interest to those intending to be present at the meeting, including any facilities offered by the railroads, etc.

In order to receive the circular of the Local Committee without fail, it is desired that all members now planning to attend the meeting should send their addresses to Rev. W. L. Gage, Secretary of the Local Committee, Hartford, Ct.

Members must furnish the Permanent Secretary with complete titles of all the papers they propose to present during the meeting, with an estimate of the time required for reading each paper. Each title must be given on a separate slip of paper, with the full name of the author. The titles must be furnished to the Permanent Secretary, when practicable, before the day appointed for the Association to convene.

The volumes of the Proceedings of the Association (22 in number) can be obtained from the Permanent Secretary, at the price of $1.50 a volume; any member wishing for ten or more volumes, in order to complete a set, may obtain them at $1.00 a volume.

3. *The Constants of Nature—Smithsonian Miscellaneous Contributions* (255). *Part I, Specific Gravities; Boiling and Melting points; and Chemical formulæ.* Compiled by FRANK WIGGLESWORTH CLARKE, S. B. 203 pp. 8vo. Washington: Smithsonian Institution.—Whoever has the patience and assiduity to compile in a careful and systematic manner such data as form the staple of this volume of "Constants," performs a service for which he merits and will receive the sincere thanks of all who find occasion to use the result of his labors. Prof. Clarke introduces his work with a list of the more important of the papers used in compiling these tables, to the number of 86 titles. The number of distinct bodies, the constants of which are given in the tables, is 2572, and there are over 5000 determinations of specific gravity, and more than 2000 determinations of the boiling point. The substances cited are classified in a sufficiently systematic manner, under 61 separate heads, and references are further facilitated by a copious alphabetical index, covering 23 closely printed pages in triple columns. Prof. Henry, as Secretary of the Smithsonian, has lately issued a circular calling on investigators and observers to send in any data of their own determinations of similar constants, with a view to the compilation of similar works in other departments of physical research. B. S.

4. *Fifth Annual Report of the State Board of Health of Massachusetts.* 550 pp. 8vo. Boston, 1874.—This Report contains, among others, a valuable paper by Prof. W. R. Nichols on the present condition of certain rivers of Massachusetts, together with considerations touching the water-supply of towns. This elaborate paper contains the results of over 450 chemical analyses, made daily upon the chief rivers and lakes, and on sources of water-supply in eastern Massachusetts, which present the ammonia, "albuminoid ammonia," inorganic and organic or volatile solid constituents, both from the unfiltered and the filtered waters, the chlorine and in some cases the lime, magnesia, silica, sulphuric acid, etc. It is noteworthy that the bulk of this analytical work was performed by a lady, Miss Ellen H. Swallow, A. M., in the laboratory of the Massachusetts Institute of Technology, where Prof. Nichols is in charge. The questions of contamination by sewage and the work of manufactures, dilution, filtration, etc., are all carefully considered from experimental data. Another paper of chemical as well as hygienic interest is that on "The use of zinked or galvanized iron, for the storage and conveyance of drinking water,"

by Dr. W. W. Rodman of Boston, whose researches sustain the conclusion that the small amount of zinc, dissolved in drinking water, passing through zinked pipes, is without injury to health, which is much more than can be truly said of lead. The hygienic and sanitary papers in this volume, under the editorship of Dr. George Derby, are of permanent value. B. S.

5. *Report on the Condition of the Sea Fisheries on the South Coast of New England in* 1871 *and* 1872; by SPENCER F. BAIRD, Commissioner. With supplementary papers. Washington, 1873–4. 8vo, 899 pages, with 38 plates and 3 maps.—This is the first volume published by the U. S. Commission of Fish and Fisheries. It contains a report of the Commissioner concerning the general character and progress of the investigations, with a summary of results and discussions of the condition of the fisheries; a large amount of testimony taken in 1871 and 1872 in reference to the present and past condition of the fisheries; reports of various State Commissioners; arguments for and against protective laws; and various other interesting papers relating to the fisheries of America and Europe; statistics of the fisheries of southern New England; natural history of some of the most important food-fishes, including the blue-fish and scup; description of the apparatus used in capturing fish on the sea-coast and lakes of the United States, with a list of the U. S. patents granted for the invention of apparatus used in the fisheries; catalogue of the marine Algæ of southern New England, by Dr. W. G. Farlow; report upon the invertebrate animals of Vineyard Sound and adjacent waters, with an account of the physical characters of the region, etc., by Prof. A. E. Verrill, with accompanying papers on Crustacea, by Mr. S. I. Smith; catalogue of the fishes of the east coast of North America, by Prof. Theodore Gill; list of fishes collected at Wood's Hole, by Prof. S. F. Baird; and a table of the temperatures of the water at Wood's Hole during the year 1873.

From this condensed summary of the contents, some idea may be obtained of the great amount and variety of the information brought together in this volume, which will mark a new era in the history of our fisheries, if not in the general study of our marine zoölogy. Although most of this volume was printed early in 1873, it was not generally distributed until April, 1874. It is furnished with copious indexes and tables of contents, and is illustrated by over 300 figures.

6. *Centennial of Chemistry*, 1774–1874.—A proposition has been made by Dr. H. Carrington Bolton, in a letter in the "American Chemist" for April, that American chemists should meet on the 1st of August, 1874, at some pleasant watering-place, to make special recognition of the year 1774, rendered memorable by so many important discoveries in chemical science, and especially by the discovery of oxygen by Priestley, on the first day of August, 1774. Such a reunion as that proposed would offer many pleasant features of attraction, and an opportunity to discuss interesting chemical topics, and review the wonderful progress made in the past century.

Dr. Bolton's proposition is approved by the Editor of the American Chemist (N. Y.), who invites from others an expression of their views, that the project may be at once put into a practical form in time for the season proposed. Why not make this chemical reunion a prominent feature of the August meeting of the Association for the Advancement of Science at Hartford? B. S.

7. *Observations on the Genus Unio, etc.*, by ISAAC LEA, LL.D. Vol. XIII.—Dr. Lea has here added another volume to his large work on the Unionidæ. It is illustrated by 22 beautiful lithographic plates representing the species described. The volume consists of two papers read before the Academy of Natural Sciences of Philadelphia; one, on fifty-two species of Unionidæ, read in September, 1873; the second, a Supplement, on fifteen species, read February, 1874.

Dr. Lea has also issued recently a pamphlet of 24 pages, containing papers from the Proceedings of the same Academy, read during the five years past, five of them on new species of Unionidæ, one on species of several genera of freshwater shells, and two on microscopic crystals in some minerals. These two last are illustrated by a plate. The minerals examined were garnets, asteriated sapphire, labradorite, a black feldspar, barite, amethyst, ruby.

8. *Hartt on the Geology and Physical Geography of the Lower Amazons.* (Bull. Buffalo Soc. Nat. Sci., No. 4, vol. i.)—Professor Hartt's paper gives new information on the features and geology of the Lower Amazons. In the Ereré district he obtained various Devonian fossils, and determined the beds of the great plain north of the Serra of Ereré, to be of Devonian age. The fossils, according to R. Rathbun, who made careful comparisons with Professor Hall's specimens at Albany, include *Rhynchonella dotis?* Hall, *Tropidoleptus carinatus* Conrad, *Vitulina pustulosa* Hall, *Discina Lodensis* Hall, *Lingula spatulata* Hall, besides new species of *Spirifer*, *Terebratula*, *Retzia*, *Rhynchonella*, *Streptorhynchus*, *Chonetes*, and *Lingula*. Part of the species are identical with New York Hamilton fossils.

9. *On Ocean Currents.*—Professor JAMES CROLL, of the Geological Survey of Scotland, has published Part III of his series of papers on Ocean Currents in the Philosophical Magazine for February. It treats of the Physical Cause of Ocean Currents.

10. *Annual Report of the Trustees of the Museum of Comparative Zoology at Harvard College in Cambridge, together with the Report of the Committee of the Museum for* 1873. 30 pp. 8vo. Boston. 1874.—In an Appendix to these Reports, it is stated that the sums subscribed for the Museum, in addition to the regular income, in 1872 and 1873, amount to $175,909.61, and that, of this sum, about $18,000 were given by Alexander Agassiz for publications, etc., $16,252 by Alexander Agassiz and Quincey A. Shaw, and $100,000 by Quincey A. Shaw. Of the remainder, $5,000 were subscribed by Mrs. G. H. Shaw, $2,000 by Mr. M. Brimmer, $4,060 by former pupils of Prof. Agassiz's Young Ladies' School, $5,500 by a "friend," and $25,000 was a grant

from the State, conditional on the same amount being raised by the Museum.

11. *Bulletin of the Minnesota Academy of Natural Sciences*, for 1874. Minneapolis, 1874. (Price 50 cents.)—Among the articles in this Bulletin, there are: a Report on the Birds of Minnesota, by P. L. Hatch, M.D.; List of the Mammals of Minnesota, by A. E. Ames, M.D.; and Geological Notes from early explorers in the Minnesota Valley, by N. H. Winchell, an important paper containing facts bearing on the distribution of the Archæan in that region.

12. *Errata to papers in this volume by Professor Verrill:*

Page 39, line 45, for *Ophiocnida hispida*, read *Ophiacantha spinulosa*. Page 138, last line, for *Urosalphinx*, read *Urosalpinx*. Page 413, next to last line, for *Phakerellia*, read *Phakellia*.

OBITUARY.

Professor JOHN PHILLIPS, Professor of Geology in the University of Oxford, and eminent for his labors and works connected with his favorite science. died on the 24th of April.

The death of Mr. Phillips was the result of an accident. On the 23d of April he had been dining at All Soul's College, and was returning, accompanied by the Principal of Jesus College, when, in crossing the top of a staircase, his foot unhappily slipped and he fell headlong down a flight of stone stairs. Paralysis and unconsciousness came on instantly, and about one o'clock on the 24th he expired. He was just seventy-three years of age.

Left an orphan at eight years old to the care of his uncle, William Smith, well known as "the father of English Geology," he was as one may say "to the hammer born." His connection with the Yorkshire Philosophical Society dates back to 1826, and with the British Association from its establishment in 1831; indeed, "he was the life and soul of its annual reunions."—*Geol. Mag. for May.*

JOHANN HEINRICH VON MÄDLER, the astronomer, and author, with Beer, of "Der Mond" and the accompanying "Mappa Selenographica," died at Hanover on the 14th of March, having been born at Berlin on the 29th of May, 1794. In 1840 he became Professor of Astronomy at the University of Dorpat, and Director of the Observatory, as successor to W. Struve.

Mineralogisches Lexicon für das Königreich Sachsen, von August Frenzel. 380 pp. 12mo. Leipzig, 1874. (W. Engelmann.)—Saxony is a land of mines and minerals, and this little volume is a convenient work on its mineralogy.

Report on the Department of Mines of Nova Scotia for the year 1873. 88 pp. 8vo. Halifax, N. S., 1874.

Annual Report upon the Survey of the Northern and Northwestern Lakes, in charge of C. B. Comstock, Major of Engineers, U. S. A., being Appendix BB. of the Annual Report of the Chief of Engineers for 1873.

Palæontologica Indica.—Series viii, 3, 4, 5, Cretaceous Fauna of Southern India, Vol. iv, 3, contains the Echinodermata, by F. Stoliczka; Vol. iv, 4, contains the Corals or Anthozoa, with notes on the Sponges, Foraminifera, Anthozoa, by F. Stoliczka. Series ix, 1, Jurassic Fauna of Kutch, Vol. i, 1, contains the Cephalopoda (Belemnitidæ and Nautilidæ), by William Waagen.

There have also appeared the *Memoirs of the Geological Survey of India*, Vol. x, part 1, containing the Geology of Madras, by R. B. Foote, and of the Satpura Coal Basin, by H. B. Medlicott; also the *Records*, Vol. vi, parts 1, 2, 3, and 4.

INDEX TO VOLUME VII.*

* The Index contains the general heads Botany, Geology, Mineralogy, Zoology, and under each the titles of Articles referring thereto are collected.

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