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TRANSACTIONS

OF THE

NEW YORK ACADEMY OF SCIENCES.

REGULAR BUSINESS MEETING.

October 3rd, 1892.

Vice-President, DR. BOLTON, in the chair.

Thirty persons present. The minutes of the Stated Meeting of June 6th were read and approved.

The report of the Council was read, recommending:

1. The change in issuing the Transactions, by which Fellows and Members may have Signatures or paper bound volumes as they may elect.

2. The election of Dr. Morris Loeb as a Resident Member.

3. The plan of holding a general meeting of the Scientific Alliance, during the Autumn. The recommendations were approved and the Secretary was directed to cast a ballot electing Dr. Loeb. The Secretary reported having cast the ballot and Dr. Morris Loeb was declared duly elected. The following proposals for Resident Membership were read by the Secretary:

Alfred J. Moses, Columbia College.
Lea McI. Luquer, Columbia College.
Francis P. Smith, U. S. Navy Yard, N. Y.

For *Fellows:*

Henry F. Osborn, Columbia College.
James F. Kemp, Columbia College.
Arthur Hollick, Columbia College.

The names were referred to the Council for action.

Dr. Bolton read a communication from Cairo, Egypt, dated, August 29th, 1892, and containing a sealed envelope enclosing a drawing of an apparatus for producing perpetual motion. The paper has been deposited with other papers of the Academy.

Dr. Britton reported that the Audubon Monument was nearly completed and that the ceremonies of unveiling would take place in the course of a few weeks.

Prof. D. S. Martin called attention to the death of Prof. Wm. P. Trowbridge and on motion the chair appointed Profs. Chandler, Martin and Rees, a committee to draw up and present suitable resolutions to the Academy.

A paper was read by Dr. N. L. Britton on Ranunculus repens L. and its Eastern North American Allies, illustrated by specimens.

RANUNCULUS REPENS AND ITS EASTERN NORTH AMERICAN ALLIES.

By N. L. Britton.

Owing to the tendency to keep the number of species as small as possible, which has characterized the work of many American botanists from the time of Nuttall to the latter years of Dr. Gray's life, many of our plants have been imperfectly understood. This is notably true in the case of the Buttercups here discussed. In the Torrey and Gray Flora of 1838, the group was divided among *R. repens*, L., with two varieties, and *R. hirsutus*, Michx. In the first edition of Gray's Manual (1848), *hirsutus* was dropped and *R. fascicularis*, Muhl., admitted; and this arrangement was maintained in the subsequent editions including the fifth (1867), and was also followed by Wood in his Class-Book, and Botanist and Florist. In Dr. Gray's books the difficulty about *R. repens* was disposed of by the statement that it is "extremely variable in size and foliage." Meanwhile everybody that looked at the plants at all critically was unable to determine them satisfactorily.

In 1886, when Dr. Gray took up the Ranunculaceæ for the Synoptical Flora (Proc. Am. Acad., xxi. 363 et seq.) he had quite changed his mind on the limitations of species, having had the experience of unraveling the Gamopetalæ behind him, and the advantage of much more material for study accumulated in the Cambridge Herbarium. He then recognized three eastern species, *R. repens*, L., *R. septentrionalis*, Poir., and *R. fascicularis*, Muhl. The name *R. hispidus*, Michx., used by Torrey and Gray in 1838 for one of the species, was now employed by Dr. Gray for a different one, in this following Hooker, Fl. Bor. Am. i. 19.

My observations have led me to conclude that *R. repens*, L. and *R. fascicularis*, Muhl., are well defined in this last paper of Dr. Gray. But under his *R. septentrionalis*, Poir., it seems to me that there are at least two species. He notes that he takes this "to include the greater part of the assemblage of forms which have passed for *R. repens* in this country."

1. Ranunculus repens L. Sp. Pl. 554 (1753).

This European species is sparingly naturalized in southeastern New York and New Jersey, being much less abundant than either*R. bulbosus*, L., or *R. acris*, L., the common field buttercups of the region. It occurs from Nova Scotia and Ontario to Virginia and is reported from various places in the interior. Dr. Gray notes that it is indigenous in some places, but I have no other evidence of this. On the label of a specimen collected by Mr. Coville at Oxford, N. Y., in 1886, Dr. Gray has written "truly indigenous," but Mr. Coville tells me that this is a mistake. Dr. Gray indicates that it extends to New Mexico.

It is a creeping, stoloniferous plant, with some of the branches ascending, and grows in dense patches along roadsides, etc., preferring moist soil. It is quite glabrous or somewhat pubescent; its leaves are pinnately tri-foliolate, very broadly ovate or orbicular in outline, the segments broad, deeply incised and lobed, and usually, so far as I have observed the fresh plant, blotched at the base of the lobes; the flowers are as large as those of *R. acris*, the petals much longer than the spreading sepals; the mature achenes are oval, slightly longer than broad, narrowly margined and abruptly tipped with a short, subulate, nearly straight style, not more than one-fourth of their length.

2. Ranunculus Macounii.

Ranunculus hispidus Hook. Fl. Bor. Am. i. 19, (1830), not of Michx.

This is a spreading or trailing hirsute species, not stoloniferous, so far as I know, occurring from western Ontario to British Columbia, and south in the Rocky Mountain region to Arizona and New Mexico. It is readily distinguishable from *R. repens* by its larger leaves, stronger habit, obovate petals scarcely or not at all longer than the reflexed sepals, and almost marginless, slightly larger and flatter achenes, which are tipped with a shorter, slightly stouter style.

R. hispidus of Michaux is, as will be shown, one of the long-styled plants included by Dr. Gray in *R. septentrionalis.*

R. Macounii has its nearest affinity in *R. Pennsylvanicus* which differs in its erect stem, smaller flowers, more finely divided leaves with still narrower segments and oblong or cylindric head of more numerous and smaller achenes, and is of eastern distribution.

3. RANUNCULUS HISPIDUS Michx. Fl. Bor. Am. i. 321 (1803).

I have seen the type of this plant in Michaux's Herbarium at the Jardin des Plantes, and it is clearly a common plant of the Eastern and Middle States and not at all the western species called *hispidus* by Hooker, which Michaux, in all probability, never saw, Dr. Gray's remarks (Proc. Amer. Acad. xxi. 375) to the contrary notwithstanding. It is an early-blooming woodland species, often flowering about New York as early as April 15th, and much before any of the other buttercups. It is not stoloniferous so far as I have observed; the young stems are usually densely villous-pubescent but become glabrate or appressed-pubescent in age; the roots are numerous, thick and fleshy, the leaves are pinnately three-divided (very rarely pinnately five-divided), very pubescent, at least when young, the segments ovate, oblong or obovate, nearly cuneate at the base, and sharply cleft and lobed; the flowers are a half inch to one and one half inches broad, with petals considerably longer than the spreading sepals; (usually twice as long) the head of fruit is usually somewhat longer than thick, though often globose; the achenes are nearly orbicular, lenticular, narrowly margined and, when mature, abruptly tipped by a subulate-curved style of about one-half their length.

The species was taken for *R. fascicularis* Muhl., by Schlechtendahl, Animad. ii. 30, t. II., (1819), who gives a very good figure of it, and it was also so-called by Austin, Leggett and other New York botanists. In Torrey and Gray's Flora, N. A., and in Torrey Flora, N. Y., it appeared as *R. repens*, var. *Marylandicus.* In my catalogue of the Plants of New Jersey it appeared as *R. fascicularis*, and I take this opportunity of stating that so far as I know, *R. fascicularis* does not occur in that

State. The range of the species appears to be from Ontario to Georgia, west to Michigan, the north-west territory and apparently to Texas. In my opinion this species is more nearly related to *R. fascicularis* than to *R. septentrionalis.*

4. Ranunculus fascicularis Muhl. Cat. 54 (1813); Bigel. Fl. Bost. 137 (1814).

A strongly-marked species capitally figured both by Hooker, (Fl. Bor. Am. i. t. 8), and Gray, (Gen. Ill. i. t. 9)., characterized by oblong or linear oblong obtuse lobes to the mostly pinnately divided leaves, the lobes of the earliest leaves much broader than those of the subsequent ones. The achenes are lenticular, closely resembling those of the preceding species, but are scarcely margined, and tipped with a subulate style of nearly or quite their length. The plant begins to bloom in the Middle States (Lancaster, Penn., *Small*) early in April. It grows on dry hillsides, etc., and has a cluster of thick, fleshy roots, like those of *R. hirsutus.*

I have not seen the type of this species but it was examined by either Dr. Torrey or Dr. Gray, as is indicated in their Flora of N. A.

5. Ranunculus septentrionalis Poir, in Lam. Encycl. vi. 125 (1804).

I am following Dr. Gray, (Proc. Am. Acad. xxi. 376) in applying this name, guided by his naming of the specimens in his own herbarium and in ours, but I have not seen Poiret's type, which ought to be in Lamarck's herbarium at the Jardin des Plantes. Dr. Gray does not say that he has examined it. Poiret's description is not altogether satisfactory, but until just what he had shall be absolutely determined, it is as well to use this name, although it may be noted that the name *R. lucidus*, Poir., (loc. cit. 113), a species based on a cultivated plant of the Paris Garden and supposed by the author to have come from the Levant, is associated with the species by Dr. Gray, and has twelve pages priority of place in publication.

The plant which I have in mind is an inhabitant of ditches, swamps and river-shores, is abundantly stoloniferous, sometimes forming runners two feet long, and about New York blooms nearly a month later than *R. hispidus*, Michx. It is often entirely glabrous, sometimes pubescent, is much stronger in growth and has larger leaves than *R. hispidus*, with acute, sharply incised or serrate segments; the flowers are often more than an inch broad; the achenes are strikingly different being oblong, with broad, often thick margins, and the beak is stout, sword-shaped, flat and nearly as long as the body of the achene.

The species ranges from the maritime Provinces of Canada to Minnesota, south at least to Pennsylvania and Kentucky. I am not sure that it occurs further south and it is certainly most abundant northward.

6. RANUNCULUS PALMATUS, Ell. Sk. Bot. S. C. and Ga. ii. 60, (1824).

This plant of pine-barren swamps and river-shores of South Carolina, Georgia and Florida, included in *R. septentrionalis* by Dr. Gray, but maintained as a species in Dr. Chapman's Southern Flora, appears to me as perfectly distinct. It is a very weak, slender species, forming long runners, is somewhat hirsute or glabrous, and has ternately divided, comparatively small thin leaves with obtuse, cleft and dentate segments. The flowers in specimens from Dr. Chapman are less than a half-inch broad, the achenes are few (3-6), oblong, very broadly margined and provided with a stout, flat, sword-shaped beak.

These six species may be briefly diagnosed as follows :

Beak of the achene less than half its length.
- Petals much longer than the spreading repals. 1. *R. repens.*
- Petals equalling or shorter than the reflexed Sepals. 2. *R. Macounii.*

Beak of the achene more than half its length.
- Beak subulate, curved. Leaf-segments broad, oblong or obovate. 3. *R. hispidus.*
- Leaf-segments narrow, oblong-linear. 4. *R. fascicularis.*

Beak stout, triangular, sword-shaped.
- Leaf-segments acute; flowers large. 5. *R. septentrionalis.*
- Leaf-segments obtuse ; flowers small. 6. *R. palmatus.*

Prof. Martin exhibited samples of Rock Salt from the mines at Leroy and Livonia near Rochester, N. Y.

Remarks on Summer Work were made by Mess. Britton, Bolton, Casey, Jacoby, Rees, Osborn, Dean, Martin, Wilson and others.

Prof. Osborn announced that the Section of Biology would organize after the adjournment of the Academy and invited members to take part.

Meeting adjourned.

STATED MEETING.

October 10th, 1892.

The President, DR. HUBBARD, in the chair.

Twenty-three persons present.

There were no minutes to be approved.

The Secretary read the following proposals for membership.

Edmund B. Wilson, Columbia College.
Arthur Willey, Columbia College.
J. L. Wortman, Am. Mus. Nat. Hist.

The proposals were referred to the Council for action.

The Secretary announced important changes in the programme for October, as follows:

OCTOBER 17—Biological Section. (Zoology and Botany)

BASHFORD DEAN, "Habits of the Venus Fly Trap of North Carolina."

N. L. BRITTON, "Note on a species of *Hieracium*."

E. B. WILSON, "Artifical production of Twins and Multiple Embryos in *Amphioxus*."

H. F. OSBORN, "The Cretaceous Mammalia in Am. Mus. Nat. Hist."

HENRY F. OSBORN, *Chairman*.

BASHFORD DEAN, *Secretary*.

OCTOBER 24—Paper by PROF. JAMES F. KEMP, on "A Review of the Geological Work hitherto done in the Adirondacks."

OCTOBER 31—Public Lecture Course. Lecture by Prof. CHARLES F. CHANDLER, on "Aluminium," illustrated,

and stated that notice would be sent to all members of the Scientific Alliance.

Prof. D. S. Martin read a paper on:

The Influence upon Science of the Discovery of the New World.

At the close of the paper Dr. Britton stated that a species of Maize or Indian Corn had been discovered growing in the wild state in Central America, and that the cultivated plant was undeniably a production of the Americas, where it has been under cultivation from remote antiquity and was found a staple article of food by the early discoverers.

Dr. Hubbard contributed the following notes:

INDIAN CORN.

LAWSON, JOHN.—A new voyage to Carolina, 1709, Lond. p. 75 "The Indian Corn or Maize proves the most useful grain in the world and had it not been for the fruitfulness of this species it would have proved very difficult to have settled some of the plantations in America.

It is the most nourishing for a man to subsist on without any other victuals."

Dr. Dwight (Pres. Yale Col. 1795) Travels Vol. 2. p. 312 "The Sweet or Shrivelled Corn so called because when ripe the kennels are remarkably shrivelled (white, one variety grows) and the 'Long Island Sweet' (white 2 varieties —8 rows Sweet—12 rows insipid) which is large and comparatively late, is when in the Milk, the most delicious of all culinary Vegetables.

The "Sweet" may be planted so early as to furnish *seed* for a second crop which will come to perfection the same season in New Haven. Travels Vol. 1. p. 49. At New Haven the Sweet Corn may be had in full perfection for the table by successive plantings from the middle of July to the middle of November. I commonly plant at twelve different periods in the season.

Dr. Dwight at *the same time* cultivated Tomatoes for the table.

Dec. 1. 1884, at a meeting of the Academy I asked Col. Ely S. Parker about "Sweet Corn." He replied "When a boy I asked my Father, a Seneca Indian, 'Where the Indians got Sweet Corn? and he said with emphasis. "The Indians always had Sweet Corn and the Cree corn of the Rocky Mountains which grows only 2½ ft. high and very nice"

He scouted the statment of Mr. John B. McMaster "That *Sweet Corn* was unknown in 1784."

Sweet Corn is believed to have been brought to Mass. in 1779 by Lieut. Bagnall on his return from Sullivan's Expedition up the Susquehanna and Western N. Y, and then became widely distributed by Connecticut settlers, as I know, throughout the Western States and beyond the Mississippi to its early homes.

Meeting adjourned.

STATED MEETING.

October 17th, 1892.

The President, DR. HUBBARD, in the chair.

Thirty five persons present.

The minutes of October 10th were read and approved.

The Secretary proposed as a Resident Member; Frederic S. Lee, of Columbia College. The nomination was referred to the Council.

There being no further business the Academy adjourned.

The Biological Section then organized with Prof. Henry L. Osborn in the chair and Dr. Bashford Dean as Secretary.

The following is an abstract of the proceedings:

The papers of the evening were:—

"Dionaea. Its life habits under native conditions. From observations made near Wilmington, N. C.," by Bashford Dean.

DIONAEA.

Its life habits under native conditions. From observations made near Wilmington, N. C. (April, 1891.)

BY BASHFORD DEAN.

Accounts hitherto given throw but little light upon the actual life habits of Dionaea, and give but a general idea of a locality, which perhaps is of a peculiar character to account for an extremely restricted range. The observations of the Rev. Dr. Curtis, * and of Dr. Canby, † both at Wilmington, preceded

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* Boston Journal of Nat. Hist., V. 1, 123, 1837, and Catalogue of Plants Growing Spontaneously around Wilmington, 1834.
† Gardoner's Monthly. Phil., Aug. 1868.

the studies of Darwin and were naturally directed in an experimental way towards the plant's digestive powers, and furnished little more than an outline of its actual predatory habits. Other local accounts appear to have been of a somewhat exaggerated charactər in regard to both the size and the quantity of prey that has been taken. On the other hand ideas of the life habits of the plant can hardly be regarded as accurate based upon hot-house specimens that have become more or less artificialized, and have lacked the kind and quantity of usual food elements. It has seemed accordingly in the case of a plant as local as Dionaea, especially desirable to determine more accurately the degree to which the specialized traps are active in providing food, (2), the kind of material collected, and (3), the ways and means followed in the collecting process. Results thus obtained might, if noteworthy, prove of value in directing lines of study in this peculiar branch of plant physiology.

Dionaea is almost exclusively confined to the Savannahs directly eastward of Wilmington, a tract of perhaps a dozen miles in length. In this tract the plant is plentiful only at special points, as a mile east of Wrightville, a few rods south of the shell road. Here, as an instance, have been counted as many as fifty plants to a square yard. The supply, however, is in general a limited one, and is decreasing year by year, mainly, it is said, on account of the great increase of forest fires and the subsequent clearing up of the land. The plant's northern range appears to be sharply drawn at the Cape Fear river.* West of Wilmington the plant occurs but is said to be rare. Southward it is still more uncommon ; it has been taken by Mr. Walter Hoxie, of Beaufort, S. C., on Fripp's Island, on Coxspur Island off the Georgia coast, and once at the head of Mosquito Lagoon below St. Augustine.

The home of the plant is in the typical Savannah, rough sedgy meadow land sprinkled with scanty yellow pines, clumps of stunted beeches broken here and there by shallow sphagnum pools. The pools are quite characteristic of the region, occupying depressions often not more than a yard across and usually but a few inches in depth. The edges are shelving, denuded, often abrupt, showing in section a layer of surface black mould above yellow-white sand. Grasses and sedges grow down to the brink and bend over, often drooping their blades into the shelving basin below. It is at the edges of the grass clumps that Dionaea frequently occurs, often displaying its trap leaves on the bare margin of the basin. This position, though appar-

* Wood and McCarthy, Wilmington Flora, Raleigh, 1887.

ently a sheltered one, may not be disadvantageous ; an insect crawling from the pool must first pass the fringe of traps, or, flying unskillfully, is not unapt to find its way to the bases of the marginal grasses. The late Dr. Thomas F. Wood, of Wilmington, to whose suggestions and kindness I have been greatly indebted, pointed out to me that the plant is not, as often supposed, a native of dry and sandy flats, nor, like Drosera, common on moist mud flats, nor yet on the high brinks and plant covered banks of large stagnant pools. It appears to be less general in its actual place of occurrence than the common predatory plants that are well represented in this region. The locality is even in a noteworthy degree rich in insectivorous species. At one point, for example, within a radius of four feet were noted Dionaea, three Droseras (longifolia, brevifolia, rotundifolia), two butterworts (Pinguicula lutea, vulgaris), and the purple Sarracenia.

At the time of my visit, (Mar. 30—Apr. 5) the plants had not yet reached their maximum growth, the largest trap measuring 1 1-4 inch in length, the leaf stalks appearing much shorter, 1 to 2 inches, and more delicate than had been expected. The color of the large traps was especially different from that observed in hot-house specimens, the inner side of the large eaves deep brownish purple, developing into scarlet and pink at the edges, the younger leaves darkening from the mid-rib outward.

The Disposition of the Traps and the Plant's Feeding Habits.

In his historic study of Dionaea, Darwin refers to "The manner in which insects are caught," and notes that among the insects entrapped in the fourteen leaves sent him by Dr. Canby, from North Carolina, but one proved to be a typical flying insect. This note is so suggestive of life habits that it is remarkable that the author did not follow it up and discuss the plant's adaptation in capturing ground insects. When looked at in this light Dionaea appears to be remarkably specialized, and would merit the name 'ant' or 'beetle catcher,' rather than 'fly-trap.' The traps, in the first place, are found expanded not in the air but on the ground * and appear to be specially adapted for this position in as much as (1) a joint occurs between petiole and blade which renders it possible for the trap to adjust itself to the ground, and in as much as (2) the tip of the trap which is usually

* Of one hundred full grown traps there were ninety whose tips were adjusted to the ground, six whose sides rested upon the ground, and but four whose traps did not descend.

fitted to the ground is destitute of marginal spikes. Second, the clustre of radial leaves is admirably disposed in position and succession * to cover accurately the extent of allotted ground. Third, the leafy petioles present a well designed runway, passing from central bud to trap, which an insect is more than apt to follow as a method of escape, after it has run the gauntlet of trapping leaves.

The actual disposition of the trap when, so to say, set, may thus be stated. The leafy petiole sprouts boldly upward, then descends gradually towards the trap. At first its face is narrow and flat, then its leafy margins begin to spread out laterally more and more until the trap is reached; these leafy margins bend upward, often curling over, and thus form a creased runway, admirably fitted to keep a visiting insect in the broad descending path. The leaf-stalk is decidedly springy it its backward curve, so much so that if its base be severed it writhes backward describing normally a curve of about 200°. Irritation of the stalk may thereafter cause the total flexure to become about 400°. This remarkable springiness appears to bring with it three important functions, (1) it causes the outer margin of the trap to be closely pressed to the ground—a position that is accommodated by the lamino-peliolar hinge, (2) it steepens the final descent of the runway, tending to prevent the retreat of visitors, and (3) it helps to adjust with nicety the leafy edges of the petiole to the sides of the trap and prevents interstical escapes. † The ascending portion of the runway has been carefully examined for aids to climbers, but these do not apparently occur. There are no hairs even along the margins, the ascent is smooth, a bit vascular, a condition perhaps of advantage to the padded feet of visitors. This moistness is somewhat viscid, judging from the dust and minute granules usually adherent. The trap itself in its disposition appears to be singularly adapted to its environment, not merely in the degree in which it opens but in the concavity of its lobes and in the bend of its marginal spikes. In the position commonly assumed the tip of the trap rests upon the ground, the lobes arching slightly upward are inclined to each other at an angle of about 50°, their concavity is well marked, the spikes inclining slightly inward. This position appears to be the one of

* C. F. Lubbock, Leaves, Flowers and Fruits, in regard to leaf disposition for other functions, e. g., respiration.

† The position of the trap, the degree to which it is open, the amount of bending of the joint, seem to determine the nicety of the adjustment of the springy margins—these, when the angle between petiole and blade, becomes marked, are usually closely opposed to the inner face of the trap, often in this way forming a kind of leafy funnel.

greatest sensitivity, judging from the results of experiments hereafter given. The traps are not usually open wider than an angle of 90°. Should, from its crowded position, the trap be disposed sidewise the supine valve loses its concavity, flattens or becomes convex, and the spikes adjust themselves to the ground and may even be of service as skids to facilitate entrance from the side; the overhanging lobe meanwhile retains its inner concavity, its spikes pointing downward.

In the process of closing, the important part played by the marginal spikes has already been discussed by Darwin; the closing, possibly by altering the convexity of the lobes, causes the spikes to rotate rapidly inward (90°), gently interlocking.

The actual process of digestion has already been carefully followed, (Ins. Pl. 295-304). Under native conditions the plant's power to emit rapidly the digestive juice, is worthy of note. Several of the leaves that had been fed with bits of earthworm and examined at the end of a half-hour had already exhibited the stout incurving of the lobe, the secretion was noticable and evenly distributed, the basal glands assuming the yellow tone, a change apparently more marked in deeply pigmented leaves. During the process of digestion the pressure of the lobes, as noted by Darwin, is sufficiently strong to outline the enclosed object. It may further be noted that at a later stage one of the lobes laps out irregularly, displayed like a protruding lip, the spines bending outward, the digestive juice sometimes oozing out. The final stage in the recovery of the leaf follows the out-rolling of the margins and the subsequent constricting of the angle of the lobes at the midrib.

In regard to time of closing the traps are irregular even to a noteworthy degree. The sensitivity, in addition, does not depend entirely upon irritation of the filiaments.

Varying sensitiveness is exemplified in the following experiments:

1. Twenty-five full grown and similarly opened traps were irritated by several strokes of wisp passing across the sensitive filiaments. Three traps failed to close; fifteen did not close sufficiently to allow the spikes to interlock, time from 2 to 10 seconds; seven interlocked firmly, time from 2 to 5 seconds. Of these seven five were but feebly pigmented and perhaps had not as yet fed.

2. A similar experiment irritating the filiaments somewhat more slowly, gave the following results: twenty-four closing, five firmly interlocking. It should be noted, however, that in these experiments the irritation had been far more severe and constant than could under ordinary circumstances be caused by

an insect. In the foregoing experiments the slighter the irritation the slighter appeared to be the chances of closing.

The nature of the irritating object does not appear to effect the rate of closing.

3. Twenty-five examples similarly irritated but with muscle of insect gave results similar to the foregoing; the time of closing varied between 1 and 20 seconds, two did not close, ten interlocked.

Continuous gentle pressure of filiaments by wisp appears to close the trap gently and slowly, a provision perhaps of strategic advantage in capturing prey.

In these experiments was noted how variable appeared to be the seat of sensitiveness. In some instances a single touch of one of the filiaments would render closing instant; in others all filiaments might be touched without causing the traps to close, or at the best would give rise to most tardy action. In one of the latter cases an accidental touch at the anterior notch in the line of the midrib caused rapid closing. This suggested the following experiments, which show that the point of closing is not altogether localized in and at the base of the filiaments (Cf. Ins. Pl. 294).

4. Ten examples were brushed by wisp along the margin of the face of a lobe without approaching the filiaments. Eight closed within 20 seconds—two of these as rapidly as if the filiaments had been disturbed.

5. Ten examples were irritated by brushing the wisp sharply across the marginal spikes. None closed.

6. Ten examples were stroked with wisp within the terminal quarter inch of the hinge. All closed within 30 seconds—three very rapidly.

7. A similar experiment irritating the posterior half of the hinge line gave practically the same results—two closing rapidly.

In these instances, however, it appears as in the experiments upon the tactile filiaments that especial interest is to be attached to the present condition of each leaf.

The foregoing experiments lead to the conclusion that the majority of opened leaves would allow insects to pass over them and would not entrap unless the visitor proved a lingering one. It seems further evident that when a leaf has acquired or regained its maximum degree of sensitiveness its instant closing may result from irritation within the trap even when the filiaments may not have been touched. The insect, however, that passes over the trap has in general an exceedingly good chance of escape, even granting that the trap commences to close. Of a number of insects allowed to pass (slowly) over the opened traps, in but one instance, that of a termite 3-8 inch in length, was the visitor entrapped in its first transit. A musk beetle, Brachinus, 3-8 inch long, passed six times between slowly closing lobes before at length captured ; a spider 1-4 inch in length escaped twice, a large curculio twice, a Harpalus four times, a small grasshopper, 1-2 inch, twice. Even when the trap has securely closed, the insect if active and of moderate size can usually effect its escape. In the above instances the musk beetle released itself within twenty minutes from time of capture, the grasshopper within thirty minutes, the Harpalus in thirty seconds. A second Harpalus more or less injured before successfully entrapped, required nearly two hours.

The rate of reopening is, again, a most irregular one, dependent probably upon the degree of the plant's sensitivity. The leaves of Exp. 1 varied in time of reopening between eight and and forty-eight hours : one which had closed most rapidly showed unmistakable signs of opening at the end of ten minutes; four which had required forty-eight hours to reopen could then only with the greatest difficulty be made to again close. In the leaves closed by irritation with insect muscle the reopening process was a far tardier one ; at the end of 24 hours two had reopened; of 48 hours ten.

In rapidity of digestion the same individual character is maintained by the leaves. In one instance the entire soft parts of an ant (3-32 inch in length) were well digested out within as short a time as 48 hours, and the process of absorption was well under way ; in another, at the end of five days the soft tissues of a similar ant were still noticable, and the glands were active in secretion.

The foregoing notes summarize the plant's natural qualifications, (1) as a capturer of ground insects, (2) as an exquisitely balanced trap passing curiously through cycles of activity. The following note is an attempt to determine quantitatively the actual feeding habits of the plant.

First, as to the proportion of the full grown leaves at one time actively occupied insectivorously Of one hundred of the largest leaves counted at random, as few as six (April 3) were found to be closed ; three, in addition, showed the ashen and dry appearance of having already fed. Three of the traps had, however, evidently closed by accident for they contained particles of soil, bark and a bit of straw ; there were no traces of secretion.

After a leaf has fed the slanted trap allows the undigested particles to gradually fall to the ground.

Second, what is quantitatively the actual material entrapped.

The contents of one hundred closed leaves were collected and gave the following results:— Eighty-five had secured material of organic origin ; of this number four-fifths had closed upon vegetable objects, bits of twigs, grasses, decayed wood, seed pods, seeds, fragments of leaves—in six of these instances digestive juices were clearly marked although careful examination failed to show traces of insects that might have furnished the usual peptogene. The scarcity of insect prey was especially remarkable, to be attributed in a measure, doubtless, to the early season. The presence of so great a proportion of ingested vegetable material is certainly significant in view of the habits of Drosera, Pinguicula and, as lately shown, Utricularia ; and it would not be altogether unreasonable to look more closely into the vegetable element of the plant's food. Of the younger leaves that were closed about thirty per cent. were found to have secured insects—perhaps on account of greater sensitivity. Insects that had been naturally taken appear to be curiously small in size ; the largest of one hundred taken from closed leaves proving not more than 1-4 inch in length, the majority of forms were scarcely more than 1-12 inch. The largest leaves appear to secure the largest insects. The proportion of the kinds of insects included might evidently be a most variable one—at that season the ground insects certainly constituted the bulk of forms. * Of one hundred insects three-quarters were, roughly speaking, ground insects, ants, beetles, small spiders, staphylinids. The remainder was almost entirely dipterous—Chironomus, a common form—occasionally a small ichneumon. As a rare article of diet should be mentioned a small moth pupa that had doubtless been contributed by the wind.

It seems most probable from the above notes that the plant's predatory nature is not as forminable as its exceedingly specialized traps might lead one to expect. Among all the leaves examined the largest captive did not exceed 1-4 inch. Cases of capture of dragon flies and large moths that have been reported must be, it would appear, of exceptional occurrence. The leaf itself does not appear to be sufficiently strong to retain the larger and more active insects, even granting that they may be securely caught. The secretion of the digestive juices, moreover, does not appear to be sufficiently rapid in its action or effects to be of material service. It is certain that the larger insects are not invariably retained as already shown by experiments. In these cases, moreover, the insects' exertions could not have been most

* The leaves received by Darwin from Dr. Canby were not improbably selected as showing signs of having taken well sized prey, consisting as above mainly of ground insects.

active owing to injuries received during the operation of securing artificial entrapment.

In conclusion, the observations upon Dionaea suggest in summary the following noteworthy characters :—

I. Specialization for the capture of ground insects.

II. The marked differences in irritability in individual leaves; the usual inability of the plant to capture and retain larger and more active insects ; the usual failure of the plant to capture transient insects ; the repeated closings of the trap upon inorganic and vegetable objects.

III. The sensitiveness of the trap in parts other than the filiaments.

IV. The marked vegetable element of the entrapped organisms, suggesting homologies in function with Pinguicula, Drosera and Utricularia, a relation more probable when we take into consideration the presence of quadrifid processes and their occurrence upon the underside of the trap.

Columbia College, Oct. 16, 1892.

"Note on a species of Hieracium," by N. L. Britton.

"Artificial production of Twins and Multiple Embryos in Amphioxus," by E. B. Wilson.

The Fourth paper, The Cretacious Mammalia in the American Museum of Natural History; to have been presented by Professor Osborn, was deferred until the following, meeting of the Section.

Professor Britton exhibited an Indian net-sinker about ten inches in length that he had found on Manhattan Island. The finding of similar relics during the excavations for the new ship canal was noted. These had been found associated with the plates of the Sturgeon.

The meeting adjourned.

Stated Meeting.

October 24th, 1892.

The President, Dr. Hubbard, in the chair.

Twenty six persons present.

The reading of the minutes of October 17th was deferred to the next meeting.

The Secretary read the following proposals:

For Resident Member:

George Huntington, M. D. Columbia College.
John G. Curtis, M. D. Columbia College.
Alfred Tuckerman, Ph. D., N. Y. City.

For Corresponding Member:

J. De Mendizabel Tamborrel, Mexico City, Mexico.

The nominations were referred to the Council.

Dr. Fiske presented to the Academy, on behalf of the author of the work, Mr. J. De Mendizabal Tamborrel of the City of Mexico, a large folio volume, containing an extended set of logarithmic tables. The chief novelty of these tables, which are carried to eight places of decimals, is the decimal subdivision of the entire circumference, which is adopted as the unit of angular measure. Their construction has led to the detection of errors in other similar tables.

Dr. Vulté exhibited a medal commemorative of the inception and completion of the Erie Canal. The case in which the medal is kept was made from a piece of wood brought from Erie, N. Y. on the "Seneca Chief," the first canal boat to pass through the entire distance. Dr. Hubbard related the history of the canal and described the ceremonies of breaking ground and completion, his remarks have especial value and interest as he was a spectator of both ceremonies.

The following paper was then read :

A REVIEW OF WORK HITHERTO DONE ON THE GEOLOGY OF THE ADIRONDACKS.

J. F. KEMP.

Abstract.

The paper was illustrated with specimens of rocks and minerals and with a series of lantern slides.

After a brief topographical description of the region, of its historical importance and economic resources, the subject proper was taken up. Reference was made to the small amount of geological work that had been done upon it. Peter Kalm, who visited Crown Point in 1749, has left a few notes, and an occasional traveler in the later years of the last century has done the same. The iron enterprises in the early years of the present century brought the geological structure into prominence. Mr. A. E. Jessup contributed to the Journal of the Philadelphia Acad. of Sci., Mar. 19, 1822, a few pages on the "Geology of the Northeast Part of N. Y." which were published in Vol. II. p. 185. He speaks of the secondary and primary rocks of Lake Champlain and of the primitive trap at Willsborough, which was visited by Dr. Wm. Meade in 1810.

The next paper of importance is that of W. C. Redfield, * who was one of a party interested in the magnetite mines at Lake Henderson. He describes their trip to the sources of the Hudson, and mentions labradorite rock, trap dikes and the great (so-called) dike at Avalanche Lake. In 1836 the bill was passed establishing the New York Survey, and in the spring of 1837 the geological parties took the field. Ebenezer Emmons received the second district, which included the mountains. For the first year James Hall was his assistant. Emmons' first annual report (1837) describes his reconnoissance of the east and west portions of the Adirondacks, and then the three sections that he made from east to west. One was at the latitude of Lake George, one at Cedar Point (Port Henry), and one on the north side. Up to Emmons' visit Whiteface was thought to be the highest peak. It was called 2,600 ft., being supposed to be 1,200 lower than Round Top in the Catskills. Emmons made it 4,885, and was the first to discover that there were higher peaks to the south, affording thus a significant commentary on the little that was known of the region. His second annual report (1838) is chiefly filled with details of St. Lawrence and Essex counties. The latter is stated to contain

* W. C. Redfield. Some account of two visits to the mountains of Essex. Co. N. Y. 1836-37. Amer. Jour, Sci. I., xxxiii, 301.

the following formations : 1. The Primary, embracing granite (*i. e.*, labradorite rock) and gneiss. 2. The Transition (*i. e.*, Cambro-silurian). 3, The Tertiary or newer Pliocene. (*i. e.*, the glacial clays, etc.). Emmons makes an extended argument to prove the igneous character of certain limestones, and in the report on the first district, Mather corroborates the idea. Emmons' second report contains also many details about iron mines, and an account of his ascent of Mt. Marcy, which he determined to be 5,467 ft.

The third annual report (1839) describes Hamilton, Clinton and Warren Counties, but is mostly devoted to the discussion of various economic minerals, peat, marl, etc. The fourth report, 1840-41, takes up the iron ores at length, especially those at Lake Henderson.

The final report appeared in 1842. The classification of formations is as follows :

A—Primary.

- I. Unstratified.
  - *a.* Granite.
  - *b.* Hypersthene rock.
  - *c.* Primitive limestone.
  - *d.* Serpentine.
  - *e.* Rensselaerite.
- II. Stratified.
  - *a.* Gneiss.
  - *b.* Hornblende (*i. e.*, hornblendic-gneiss.)
  - *c.* Sienite.
  - *d.* Talc or Steatite.
- III. Subordinate.
  - *a.* Porphyry.
  - *b.* Trap.
  - *c.* Magnetic and
  - *d.* Specular oxide of iron.

B—New York Transition System.

- Champlain Group.
  - *a.* Potsdam sandstone.
  - *b.* Calciferous sandrock.
  - *c.* Chazy limestone.
  - *d.* Birdseye limestone.
  - *e.* Trenton limestone.
  - *f.* Utica slate.
  - *g.* Lorraine shales.
  - *h.* Grey sandstone.

C—Tertiary.

It is a curious fact that the porphyry and trap classed with the primary are described as penetrating the Utica slate, and that sienite of the Statified division is also said to occur in dikes. After a chapter on the ill-starred Taconic system, the counties are taken up in order and described. In discussing the primary system, Emmons says little of the respective ages of the subdivisions, but he saw clearly the contrast of the "granite" (*i. e.*, the labradorite-hypersthene rocks) and the gneiss. It must be remembered that he worked in a wilderness and, considering his opportunities, he deserves the highest praise. He writes with extraordinary ability and clearness, and though, for instance, we have no confidence to-day in the igneous character of his limestones, we must realize that conceptions and knowledge of metamorphism have greatly advanced since his time.

The dearth of papers in the next thirty or forty years is remarkable. The Canadians had country of much the same character to deal with, and the problem of the subdivision of the old crystalline rocks was attacked by them. The Adirondacks are often referred to, but no detailed field-work was done in them. The relations of the gneisses, the norites or anorthosites and the crystalline limestones have been and are the problems meriting attention. As is well known the gneisses were generally called Lower Laurentian, and the norites, Upper.

A number of papers remain to be noted, which treat of restricted parts of the subject. The late Dr. T. S. Hunt published in 1871, a valuable contribution on the Mineralogy of the Laurentian limestones (21st Annual Report N. Y. State Cabinet, p. 47, 1871), but has comparatively little to say of their geognostic relations. James Hall presented to the American Association at the Buffalo meeting, 1876, a paper on the Age of the Serpentinous Limestones of Northern N. Y. It was published in the Buffalo Courier, Aug. 25th, and from this was abstracted for the American Journal of Science of October of the same year. Professor Hall regarded the limestones as later than the Laurentian and earlier than the Potsdam, but whether Huronian or not he does not say. The paper is rather general in character and gives no actual sections or data of localized character, at least in the printed abstract.

In 1877 Dr. Albert R. Leeds published a paper entitled "Notes on the Lithology of the Adirondacks" (Chemical News, Mar., 1877; 36th Ann. Rep. N. Y. State Cabinet, 1877, p. 79). Dr. Leeds' material came mostly from the Keene Valley and consisted of varieties of norite and of several diabase dikes. Very careful chemical analyses are given, and some microscopic determinations by Dr. A. A. Julien. The rocks (except the diabase) are shown to contain plagioclase (largely anorthite), hypersthene, hornblende, diallage, magnetite, menaccanite, and garnet. They are both massive and gneissoid. Dr. Leeds gives six conclusions. I. The rocks of Essex Co. are parts of the Norian system and are composed of norites like those in Canada, Western Scotland, Norway and elsewhere. II. That they are a stratified rock, which has undergone a metamorphism so profound as to cause them to be regarded by Emmons and others as massive. That the dolerites have come from another portion of lower lying, stratified rocks and have tilted the norites in their extrusion. III. The norites are marked by a paucity of silica due to the presence of bisilicates and to anorthite among the plagioclases. IV. The alkalies are deficient. V. Menaccanite is universal in both labradorite and pyroxenes VI. The menaccanite contains chromium. The additions made by this paper to our knowledge of the chemical composition of these rocks are most praiseworthy, but the conclusions under II. are warranted by no commensurate field-work as evinced by the paper, and, remembering the mineralogy of the rocks, they would be considered in the estimation of petrographers as untenable. (See also A. R. C. Selwyn, Rep. Prog. Can. Sur., 1877-78.)

In 1879 C. E. Hall published a paper on the "Laurentian Magnetic Iron Ore Deposits in Northern N. Y." (32nd Annual Report of the N. Y. State Cabinet, 1879, pp. 133-140.) The geology of the eastern Adirondacks is discussed very briefly by townships. The Archaean rocks are divided into: I. Lower Laurentian Magnetic Iron Ore Series. II. Laurentian Sulphur Ore Series. III. The Crystalline Limestones. IV. Labrador Series or Upper Laurentian with titaniferous ores. The relations of II. and III. are said to be uncertain, but later in a note the limestone of III. is stated to be later than IV. A geological map accompanies the report.

G. P. Merrill, of the U. S. National Museum, has given attention to the serpentinous limestones as having some bearing on the Eozoon Canadense. This problematic association of serpentine and calcite had been previously announced from Warren Co. by A. M. Edwards. (Lyceum of Natural History, N. Y., Proc., 1870, p. 96.) Two papers have come from Mr. Merrill, the one on the "Ophiolite of Thurman, Warren Co.," etc., Amer. Jour. of Sci., Mar., 1889; and the other, "On Serpentinous Rocks from Essex Co., N. Y. etc.," Proc. U. S. National Museum, XII., 595, 1890. The serpentine appears to be both an alteration product from a white pyroxene, cores of which it surrounds, and also an infiltration product that has replaced calcite.

Professor R. Pumpelly has made one or two suggestions in connection with another subject that are worthy of mention. He states in his paper on "The Relation of secular Rock-disintegration to certain transitional crystalline Schists," (Geol. Soc. Amer. II. 218, 1890,) that he walked from Fort Ann to Westport and noted often in the limestones and near their lower edges, fragments of the crystalline rocks on which they rest. These fragments, Pumpelly suggests, are the results of surface disintegration preceding the deposition of the limestone, in whose substance they thus became involved.

In the summer of 1889 and 1890, J. F. Kemp and V. F. Marsters were in the field studying the trap dikes of the region, ("Trap dikes in the Lake Champlain Valley and the neighboring Adirondacks," Trans. N. Y. Acad. Sci. XI., 13, 1891. The full paper has been accepted as Bulletin 10 of the U. S. Geol. Survey). A large number were found, including diabase and related rocks and feldspar porphyries (Bostonite). They also visited a great reported dike at Avalanche Laké, which had been noted by Redfield in 1836. It proved to be a shear-zone or a crushed and dynamically metamorphosed strip along a fault. (J. F. Kemp, "The great Shear-zone at Avalanche Lake, in the Adirondacks," Amer. Jour. Sci., Aug., 1892, p. 109.) Remarks on other faults and shear-zones conclude the paper.

Reference should also be made to the reports of the Tenth Census, in Vol. XV., on iron ores. Many details of local geology near the ore bodies are given. The report was issued about 1885. Similar mention should be made of J. C. Smock's Report on the Iron Mines of N. Y., 1889, Bulletin VII. of the State Museum.

Valuable work on the fossiliferous rocks, although chiefly on the east bank of Lake Champlain, has been done by President Brainerd and Professor Seely, of Middlebury, Vt., and Professor Whitfield, of New York. Their discoveries relate especially to the Calciferous and Chazy formations. Mr. C. D. Walcott, of the U. S. Geological Survey, has given much attention to the fringe of Potsdam. In Bulletin 81, of the Geol. Survey on the Correlation of the Cambrian Strata, cross-section, plate II, he has colored a strip on the east of the mountains as Algonkian. This presumably refers to the limestones and indicates for them an age later than the Laurentian.

The past summer (1892) the writer was in the field and will later present through the N. Y. State Museum the results of detailed observations in Moriah and Westport townships, which, however, are only a beginning of future work. On the west side Dr. C. H. Smyth, Jr., of Hamilton College, was working in close association.

In summing up on the geology of the Adirondacks, it may be stated that the following views relative to the stratigraphy of the crystalline rocks have been held.

I. It has been usually believed, that the gneisses are the oldest and are metamorphosed sediments; that the norites are later, some regarding them as igneous, others as metamorphosed sediments; that the limestones are latest of all.

If this be admitted and the norites be regarded as igneous intrusions, how is it that no dikes or apophysæ have ever been mentioned as radiating or offsetting from this enormous mass?

II. That there is a core of central and oldest norite, having later gneiss as a metamorphosed sediment on its flanks, and still later limestone on both norite and gneiss.

One or the other of these views has been held by almost every one at all familiar with the region and they have been in many minds, if not so definitely stated in print. It must be recognized that the region is badly faulted and broken, as the mines, the topography and the geology indicate. While any one of the three generally received divisions are easily recognizable in typical cases, they yet have been so subject to metamorphism that there are intermediate members of great obscurity. The region requires careful and systematic field-work, with parallel microscopic determinations. It is remarkable how little detailed work of any stratigraphical value has yet been published on the crystalline rocks.

GEOLOGICAL DEPARTMENT, COLUMBIA COLLEGE, Oct., 1892.

Prof. Osborn spoke of a singular rounded and polished hole in rock on the place of F. A. Church Esq., on the Hudson River. It is evidently a gigantic pot-hole.

Dr. Bolton asked for information concerning the supposed find of buffalo remains at Plainfield N. J. Dr. Dean and Prof. Osborn replied that they could as yet see no evidences of these remains being other than those of deer, and further that the newspaper reports of interviews were not strictly correct. Prof. Kemp remarked that he had a hippopotamus tooth said to have been discovered near Ramapo, N. J.

Meeting adjourned.

Stated Meeting

October 31st, 1892.

The President, Dr. Hubbard in the chair, two hundred and fifty persons present ; in the absence of the Secretary the reading of the minutes was omitted.

The President introduced Prof. C. F. Chandler Ph. D. of Columbia College, who delivered the opening lecture of the Course of 1892-93, subject ; "Aluminium and its Alloys." The lecture was illustrated with a large collection of articles of use and ornament made from aluminium and its alloys, among the atter were those of silver and copper, the last possessing great tensile strength, 75,000 pounds to the square inch. At the close of the discourse a vote of thanks was accorded the lecturer and the meeting adjourned.

Regular Business Meeting

November 7th. 1892.

The President, Dr. Hubbard in the chair, forty-five persons present. The minutes of October 3rd were read and approved.

The report of the Council was read, recommending the election of the following candidates for resident membership :

Alfred J. Moses,
Lea Mc I. Luquer,
Francis P. Smith,
J. L. Wortman,
Alfred J. Tuckerman,
Frederic S. Lee,
John G. Curtis,
Edmund B. Wilson,
Arthur Willey,
George S. Huntington,

and the following as Corresponding member, J. de Mendizabel Tamborrel, on motion the Secretary was directed to cast a ballot electing the various members. The Secretary reported having cast an affirmative ballot and the members were declared duly elected.

The Secretary read the following nomination for Resident member,

C. N. Jones, 346 Broadway, New York,

the nomination was seconded by John Tatlock, Jr., and referred to the Council.

The Astronomical section then organized with PROF. REES in the chair, the Secretary called attention to the following matters of interest :

1. Observations of the partial solar eclipse of October 20, made at Columbia College Observatory, and communicated to the Astronomical Journal.

2. Observations of the periodic variation of latitude, made at Berlin, Prague, Strassburg, and Honolulu by German observers. A chart showing the variation curves obtained at the stations from May 1891, to June 1892 was exhibited.

3. Discovery of a comet by *photography* at the Lick Observatory by Prof. Barnard, October 12 1892.

4. A series of fine heliogravure reproductions of Lick lunar photographs was shown. They were copies of drawings made from the Lick negatives by Prof. Weinck of Prague.

The following communication was then read by the Secretary :

To the Secretary of the Astronomical Section of the New York Academy of Sciences:—

Dear Sir :

Please announce the following notice :

On the probable connection between solar and terrestrial activity.

The terrestrial magnetic storms, the aurorae borealis and the meteorological disturbances, observed to be especially strong during the maximum period of sun spots, are due to the electrical and chemical effects of the increased quantity of ultraviolet light which the sun at the maximum period of its activity sends to the earth. The particular sources of this increment in the quantity of ultraviolet light are the sun spots, and especially, the faculae and the protuberances which, accompany the sun spots.

Yours very respectfully,

M. I. PUPIN.

Prof. Rees, for the committee appointed June 3d 1892, read an account of the life of Lewis Morris Rutherfurd, which has been published in "Astronomy and Astrophysics" for October 1892. Dr. Mason made some further remarks concerning Dr. Rutherfurd, with whom he had been associated for many years. He called special attention to Dr. Rutherfurd's method of correcting microscopic objectives for photographic purposes.

Mr. Jacoby gave an account of a visit to the observatories at Greenwich and Kew, and described the work being done at Greenwich in connection with the astrophotographic chart of the entire heavens.

Prof. Rees made some remarks on the discovery of a fifth satellite of Jupiter by Prof. Barnard at the Lick Observatory, September 9, 1892. He also referred to the recent observations of Mars at the Lick Observatory, Princeton, and elsewhere, and exhibited lantern slides illustrating some of the results obtained. The Academy then adjourned.

Stated Meeting

November 14th. 1892.

Biological Section, second meeting, H. F. Osborn in the chair, Bashford Dean, Secretary. Forty persons present; the minutes of the first meeting October 17th, were read and approved.

Permanent officers were elected as follows: H. F. Osborn, Chairman, and Bashford Dean, Secretary. An advisory committee of four, consisting of F. S. Lee, C. F. Cox, N. L. Britton, and E. B. Wilson was appointed. The papers of the evening were: "On the Pituiary body, with considerations regarding vertebrate descent" by Arthur Willey, "On recently discovered Cretaceous Mammals" by H. F. Osborn.

Additions to the Palæobotany of the Cretaceous Formation on Staten Island.

By Arthur Hollick.

In a previous communication * I gave an account of the fossil leaves found upon Staten Island which could be indisputably recognized as Cretaceous species, the object being to demonstrate the occurrence and probable extent of the Cretaceous formation in that locality.—Quite a large amount of the material then in my possession I had not determined, as noted at the close of my former contribution, and more has since come to light. All this material has recently been subjected to careful examination and comparison and the results obtained form the basis of this paper.

The remains, consisting of leaves, stems, fruits and seeds, are found in place, imbedded in the Cretaceous clays, or else in ferruginous sandstone and concretions, evidently derived from the clays, but now distributed through the glacial drift which overlies them. Those which occur in the clays are in the condition of lignite, which disintegrates upon exposure and soon renders them useless for accurate study or identification. Drawings of these were made as quickly as possible after collection but many were destroyed before they could be depicted. Those which occur in the sandstones and concretions are mostly in the nature of impressions only—the lignite having entirely disappeared. Many of these impressions are very perfect and afford exceedingly satisfactory subjects for study.

The additions number about forty species, a large part of them not before recorded from the eastern United States, although described by Prof. Oswald Heer, from Greenland and by Prof. Leo Lesquereux from the western United States. Nine represent new species in the genera *Populus, Myrica, Platanus, Ficus, Kalmia, Acer, Magnolia,* and *Williamsonia,* besides remains of uncertain affinities, consisting of leaves, fruits, and seeds.

In the study of this material I wish to acknowledge the assistance which I have obtained from Dr. J. S. Newberry's

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* Palæontology of the Cretaceous Formation on Staten Island. Trans. N. Y. Acad. Sci. xi. 96-103.

manuscript and plates of the "Flora of the Amboy Clays," soon to be published as a monograph of the United States Geological Survey. I am also indebted to Dr. N. L. Britton for assistance in comparing the fossils with living species. Credit for collecting a number of valuable specimens is due to Mr. Wm. T. Davis of the Natural Science Association of Staten Island, and to Mr. Heinrich Ries of the New York State Museum.

I have thought it best, in view of the unsatisfactory character of much of the material, to designate many of the species provisionally, trusting that future investigation may bring to light sufficient and better material for more exact determinations. The clays are being constantly excavated and plant bearing layers may be exposed at any time which may yield valuable results, so that this paper is to be considered as largely preliminary and the conclusions as subject to modification, so far as some of the identifications of species are concerned. For this reason I have refrained from attempting to describe many new species upon material so fragmentary in character, preferring, whenever possible, to refer the specimens provisionally to previously described species.

Juniperus hypnoides, Heer,

Pl. I. f. 1.

The specimen identified as above was found by Mr. Wm. T. Davis, in a clay pit at Kreischerville. It appears identical with Heer's species as represented in Flor. Foss. Arct. VI. 47, 48 ; Pl. XLIV. f.3 and XLVI. f.18. This is one of the best preserved specimens which we have from the clays and it was identified provisionally under the genus *Juniperus* when first brought to light. (Proc. Nat. Sci. Assn. S. I. September 10th, 1892.) The only other species with which I have thought this might be compared is *J. macilenta,* Heer.

Frenelites Reichii, Ett.

Pl. I. f. 23.

In many of the masses of clay examined, wherever plant remains were found, fragments and matted bundles of a conifer were generally prominent, which are almost certainly referable to this species, as represented by Ettingshausen in his Kreideflora von Niederschœna, 246, Pl. I. f. 10a-10c, and by Heer, in his Flor. Foss. Arct. VII. 51. Pl. XXVIII. f. 5. and VIII. 13, Pl. LII. f. 4, 5, under the name *Widdringtonites Reichii* Ett. sp. In our material the specimens are but little better than bundles of slender branches, consisting of lignite, which cracks and breaks upon exposure to the air, so that accurate portrayal of the specimens is almost impossible. The one represented was collected in the clays at Kreischerville. This same species has been identified by Prof. J. S. Newberry from the clays of Woodbridge, South Amboy, and Sayreville, N. J.

Sequoia heterophylla, Vel.

Pl. I. f. 21.

The above determination is founded upon a single fragment from the Kreischerville clay, which, although fairly well preserved, would be hardly sufficient to justify a positive determination did we not have an abundance of the same species with which to compare it from the clays of New Jersey, where it is one of the most common of the conifers. It is described and figured in Velenovsky's Gymnospermen der Bœmischen Kreideformation, 22, Pl. XII. f. 12 and Pl. XIII. f. 2-4 and 6-9.

Sequoia Reichenbachi, Gein ?

Pl. I. f. 18.

It is with some hesitation that I have referred this specimen to the above species. It has been identified by Dr. Newberry from the Woodbridge N. J., clays, but our specimens are merely represented by imperfect impressions in hard ferruginous concretions and are not satisfactory for determination. The one figured was found in a concretion on the shore at Tottenville.

Sequoia Couttsiæ, Heer.

Pl. I. f. 5.

There can be but little doubt that our specimen is the same species as described and figured by Heer, in his Flor. Foss. Arct. I. 94, Pl. XLV. f. 19a., 19b. from the Tertiary of Greenland. I was at first inclined to compare it with *S. concinna* or *S. fastigiata*, both of which have been found in the Cretaceous (Patoot) beds of Greenland, but our specimen is more open in its habit than are these. So far as I am aware no one of these species has yet been found in the New Jersey clays. The specimen figured was collected by Mr. Wm. T. Davis at Kreischerville.

PINUS, sp?

Pl. I. f. 13, 19, 20, 22.

This genus is represented by leaves scattered plentifully through the clays at Kreischerville, wherever remains of vegetation are found, and by a broken fragment of a large cone and a single scale, the former from a concretion found at Arrochar, the latter from ferruginous sandstone at Tottenville. Until such time as better material for study is available I have thought it best to group all these remains together, although it is probable that the leaves and cone represent distinct species, as the flora of the clay and that of the concretions and sandstone are in general distinct one from the other.

DAMMARA BOREALIS, Heer?

Pl. I. f. 17.

In Flor. Foss. Arct. VI. 54, Pl. XXXVII. f.5, Prof. Heer describes and figures organisms under this name similar to the one here shown. In the same volume, Pl. XLV. f. 4-11, organisms referred to *Eucalyptus Geinitzi* are depicted. So far as the figures are concerned they all seem to be very closely allied. Our specimen is too poor for definite comparison, but the fact that thus far the abundant presence of undoubted coniferous trees in Cretaceous times, particularly in the clays of Staten Island and New Jersey is proven, while the presence of the genus *Eucalyptus* is highly problematic, has decided me in placing our specimen under *Dammara*, but whether or not this latter is the genus to which these organisms will ultimately be referred need not here be discussed.

Locality: Tottenville, in a concretion.

[In this connection the presence of amber in greater or less abundance might be mentioned, but this could be derived from either Conifers or Eucalypts, so that its occurrence is of secondary interest only.]

POPULUS? APICULATA, Newb. in mss.?

Pl. III. f. 2.

This species, represented by the upper part of a leaf only, appears to be identical with that described and figured under the above name by Prof. Newberry, from Woodbridge, N. J., (Fl. Amboy Clays, Pl. XV. f. 3-5.) The specimen was found by Mr. Gilman S. Stanton in a block of ferruginous sandstone at Arrochar.

SALIX, sp?

Pl. II. f. 15, 16.

These two fragmentary specimens will probably be found to represent some recognized Cretaceous species of *Salix*, many of which are abundant in the Woodbridge clays, in the event of better material being discovered. Both specimens are from Kreischerville. Their affinities appear to be with *S. inaequalis*, Newb. in mss. (Fl. Amboy Clays Pl. XVII. f. 2-7.)

MYRICA DAVISII, n. sp.

Pl. II. f. 3.

Leaf entire, linear or nearly so, tapering to the base, ⅜ inch wide. Secondary nerves sub-parallel and equal in rank.

Named in honor of Mr. Wm. T. Davis, by whom it was found in the clay at Kreischerville. Its affinities are with *M. longa*, Heer.

MYRICA GRANDIFOLIA, n. sp.

Pl. III. f. 1.

Leaf lanceolate in outline, petioled. Length including petiole, about 7 inches. Width at broadest part about 1⅝ inches. Strongly dentate above. Teeth becoming smaller below and finally disappearing so that the lower part of the margin for a distance of about 1¼ inch is entire. Nerves all about equal in rank leaving the midrib at an angle of 45 degrees or less, parallel, soon becoming connected by cross veining which forms a fine reticulated network enclosing polygonal areolæ.

Locality: Tottenville, in a concretion. Its affinities are with *M. Banksiæfolia*, Ung.

PLATANUS AQUEHONGENSIS, n. sp.

Pl. IV.

Leaf about 5½ inches long by 4¼ broad at widest part. Ovate-lanceolate in outline; undulate-serrate; tapering to the apex and rather abruptly curving to the base. Nervation strong, palmate, craspedodrome. The two lateral primaries starting from the base of the leaf, forming an acute angle with the midrib and extending in a nearly direct line to the margin. About 5-7 irregular, occasionally branched, secondaries, extend from the under sides of the laterals to the margin. Secondaries from the midrib forming about four sub-parallel, sub-opposite pairs, more or less irregular and branching and sub-parallel with the lateral primaries. Tertiary nervation and areolation that of *Platanus*.

This single specimen was found during the excavation of a cellar near Richmond Valley station, on the Staten Island Railroad, and was obtained from the discoverers by purchase *. In its original position it was in a large irregular block or fragment of ferruginous sandstone buried in glacial drift.

It was compared successively with the genus *Grewiopsis Populites* and *Platanus* and its nearest allies were seen to be in the latter. It is not unlike some of the young unlobed forms of *P. Haydeni*, Newb., and had it been found in connection with Tertiary strata I might have felt inclined to place it under that species. No representative of the genus has yet been found in the New Jersey clays, but the presence of *P. Newberryana*, Heer, at Princes Bay, was noted in my previous paper, where it occurred in the same block of stone with *Thinnfeldia* and *Liriodendron simplex*, Newb., both of which are characteristic Cretaceous plants, so that the reference of this specimen to a new Cretaceous species does not seem to be unwarranted.

The specific name adopted is coined from the aboriginal name for Staten Island, *Aquehonga Manacknong*, in order that it may always be identified with the locality where it was found.

FICUS WOOLSONI, Newb. in mss. ?

Pl. II. f. 1 and 2*c*.

The two fragments here shown were found by Mr. Wm. T. Davis in the Kreischerville clay. Although too imperfect for satisfactory determination they have been placed provisionally under the above name. It has been found in the clay beds of New Jersey, both at Woodbridge and Sayreville, and has been described and figured by Dr. Newberry (Flora of the Amboy Clays, Pl. XXIII. f. 1-6).

LAURUS PRIMIGENIA, Ung. ?

Pl. II. f. 20.

Pl. III. f. 3.

Represented by the bases of two leaves. One (f. 20, Pl. II.) obtained by Mr. Wm. T. Davis from the clays at Kreischerville, the other (f. 3, Pl. III.) from a concretion found on the shore at Tottenville.

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* Proc. Nat. Sci. Assn. S. I. Mch. 12 and April 9, 1892.

LAURUS HOLLÆ, Heer?

Pl. II. f. 17.

A single fragment, representing what is apparently the base of a leaf of this species, obtained by Mr. Wm. T. Davis at Kreischerville.

DIOSPYROS STEENSTRUPI, Heer.

Pl. III. f. 8.

A well preserved impression in one of the concretions from Tottenville. It appears to be identical with the species described and figured by Heer, under the above name. (Flor. Foss. Arct. VII. Pl. LXIV. f. 1*a*, 1*b*).

KALMIA BRITTONIANA, n. sp.

Pl. II. f. 6, 7, 8.

Leaf about 1 inch long by ¼ inch wide at widest part, oblong, entire, rounded at the apex, tapering below, midrib prominent, no nervation visible, indicating that the leaf was of a thick coriaceous consistency.

Locality: clay beds, Kreischerville. Named in honor of Dr. N. L. Britton, to whom I am indebted for valuable assistance in tracing the affinities of many of the new species here enumerated.

EUCALYPTUS GEINITZI, Heer.

Pl. II. f. 5.

This specimen, although exceedingly fragmentary, shows clearly along the margin the characteristic veining of what have been described as *Eucalypti*. *E. Geinitzi* has been found abundantly at Woodbridge and has been previously noted by me from Tottenville, hence it seems reasonable to consider our fragment as belonging to this species. Locality: Kreischerville.

LEGUMINOSITES FRIGIDUS, Heer.

Pl. II. f. 11.

I am unable to find any difference between the specimen here figured, found in the clay at Kreischerville, and the figure under this name by Prof. Heer, from the Cretaceous of Greenland. (Flor. Foss. Arct. VII. Pl. LV. f. 22.)

ACER MINUTUS, n. sp.

Pl. III. f. 6.

Trilobed, midvein ⅝ inch long. Laterals $\frac{7}{16}$ inch long forming an angle of about 45° with the midvein, margin dentate.

Locality: Tottenville, in a concretion.

RHAMNUS ROSSMASSLERI, Ung.

Pl. III. f. 5.

A single specimen, found in a concretion at Tottenville. It has not yet been reported from New Jersey or the West, but it is described by Prof. Heer, from the Cretaceous of Greenland.

CHONDROPHYLLUM ORBICULATUM, Heer.

Pl. II. f. 2*b*.

Collected by Mr. Wm. T. Davis in the Kreischerville clay.

PALIURUS AFFINIS, Heer ?

Pl. II. f. 12, 14, 18, 19.

Pl. III. f. 7.

It is with some hesitation that these specimens have been referred to the above species. They are all incomplete and fragmentary but show indications of a triple nervation similar to *Paliurus*, or perhaps *Cinnamomum*. There also seems to be an indication of trilobation, as in f. 12, Pl. II, and it is possible that several genera may be here grouped together, but only by means of more complete material could this be demontrated satisfactorily. All are from the clays at Kreischerville except f. 7, Pl. III, which represents a specimen found in a concretion at Tottenville.

LIRIODENDRON PRIMÆVUM, Newb.

Pl. III. f. 4.

In ferruginous sandstone, Tottenville.

MAGNOLIA LONGIFOLIA, Newb. in mss.

Pl. III. f. 9.

Locality, Tottenville, in ferruginous sandstone.
This species was collected by Dr. J. S. Newberry in the New Jersey clays, at Woodbridge, and is figured in the Flora of the Amboy clays under the above name (Pl. LV. f. 1-4).

PROTAEOIDES DAPHNOGENOIDES, Heer.

Pl. II. f. 4, 9, 13.

This species appears to be one of the most plentiful from this region. It has been previously noted by me from Tottenville, the specimens here figured are from the Kreischerville clays and it is abundant at Woodbridge and South Amboy, N. J.*

MAJANTHEMOPHYLLUM PUSILLUM, Heer.

Pl. I. f. 7.

The specimen which is here represented is apparently identical with that figured by Heer under the above name (Fl. Foss. Arct. VII.. 18, 19, Pl. LV. f. 17, 17*b*.) Locality: Kreischerville clays.

DEWALQUEA INSIGNIS, Hos.

Pl. I. f. 9.

The single fragment represented appears to be undoubtedly the same as the species described and figured by Heer under the above name (Fl. Foss. Arct. VII. 37, Pl. LXII f.7, 7b. and Pl. LVIII. f. 3). Locality: Kreischerville clays.

DEWALQUEA HALDEMIANA, Sap.?

Pl. II. f. 10, *2a*.

Locality: clays at Kreischerville.

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* Since writing this paper I have received Monograph No. XVII. of the U. S. Geol. Survey (The Flora of the Dakota Group; Lesquereux), in which is described and figured (p. 77, Pl. XII. f. 2) under the name *Ficus protaeoides*, sp. nov., a leaf identical with one figured by me as *Protaeoides Daphnogenoides*, from Tottenville. (Trans. N. Y. Acad. Sci. XI. Pl. III. f. 1.) Whether or not this generic distinction is warranted need not be here discussed however, and I merely desire to call attention to the fact.

Williamsonia? Riesii, n. sp.

Pl. I. f. 2, 3.

Organism consisting of a discoid center around and radiating from which are numerous petaloid appendages, like the ray florets of a composite flower. Disc about 3/8 inch in diameter. Entire organism, including the expanded rays, about 1½ inch in diameter. Rays about 1/16 inch broad, linear or somewhat tapering to each end, imbricated (?) striated (?) longitudinally.

It is with some hesitation that I have placed this organism under the genus *Williamsonia*, but recent discoveries in the Cretaceous clays of New Jersey have shown the existence there of allied organisms, and its occurrence on Staten Island therefore is not surprising. I am also impelled to find place for it under this genus as otherwise a new genus would have to be erected, which would be unwise with the meagre and unsatisfactory material now in my possession. Without entering into a discussion of the probable affinities of *Williamsonia* it may be said that our species is strikingly like some composite flower. The perfect preservation of the rays however would indicate that they were composed of some material more substantial than the ray florets of our living compositæ. They might however have been of a scarious or woody consistency like we have in the scales of *Gnaphalium* and other similar flowers. Another direction in which investigation might be pursued is in the study of scaly bracted fruits like those of *Liriodendron*. We know that this tree and others, which are now represented by but a single genus or even a single species, were in Cretaceous times represented by types as diverse and numerous as the oaks of to-day and with flowers or fruit probably equally diverse, so that it would not require any great effort of the imagination to see in the organism before us a flattened portion of some such fruit. It is also worthy of remark in this connection that the rays in our specimen show indications of being imbricated, although so poorly preserved that it is not safe to state this with certainty. The specimen was found in one of the clay pits at Kreischerville, by Mr. Heinrich Ries, after whom it is named. The figures represent counter-parts of the same specimen.

Phyllites Poinsettioides, n. sp.

Pl. I. f. 10.

Leaf unsymmetrical, broad at top and tapering to the base. Apex blunt. Margin extending into two incurved teeth or lobes at the upper part, about equal with the apex, thus giving the leaf a somewhat kite-shaped outline. Midrib curved. Nerves fine and numerous, starting at about right angles from the midrib, continuing almost parallel and soon becoming campdodrome.

The only apparent comparison which I have been able to make between this curious leaf and any living one is with the genus *Euphorbia*. It closely resembles some of the bract-like leaves of species classed under the sub-genus *Poinsettia* and I have indicated the apparent relationship in the specific name.

Locality: clay at Kreischerville.

Fruits and Seeds of Uncertain Affinities.

On Plate I, a number of fruits and seeds are figured which might be grouped under *Carpolithes*, or *Carpites*, the generally recognized generic titles for such organisms; but so long as their relationships are entirely problematic it seems a wiser course to leave them unnamed.

Pl. I. f. 4, 6, 8, 11, 12, 14, 15, 16, 16*a*.

f. 4. Fruit spheroidal, composed of apparently six rounded, elongated carpels, each $\frac{3}{16}$ inch broad by $\frac{5}{16}$ inch long. Entire fruit not unlike a large dried berry of *Celastrus scandens*, L.

Locality: shore at Tottenville, in a concretion.

f. 6. Thin, flat or slightly warped, top-shaped in outline, about $\frac{1}{4}$ inch long. General appearance not unlike the achenia of some species of Cyperaceæ.

Locality: clay at Green Ridge; Heinrich Reis.

f. 8. Curved lenticular in outline, with rounded ends and a center which rises gradually from the convex margin. Concave portion of the margin and ends, winged, $\frac{5}{16}$ inch long by $\frac{1}{8}$ inch wide.

Locality: clay at Kreischerville.

f. 11. Oblong ovate, apiculate at one end, rounded at the other. Margin rounded throughout, $\frac{7}{16}$ inch long by $\frac{1}{4}$ inch broad.

Locality: clay at Kreischerville; Wm. T. Davis.

f. 16, 16*a*. Entire specimen consists of loosely arranged spike or raceme, about $\frac{3}{4}$ inch long, composed of minute fruits upon short thick pedicles. Under the microscope each fruit is seen to consist of an apiculate oval seed, partly enclosed between two glume-like appendages.

Locality: clay at Kreischerville.

f. 12. Fruit consists of a slightly raised center, surrounded by a narrow rim or margin. Outline almost circular, not quite $\frac{1}{4}$ inch in diameter. Center appearing as if filled with small seeds. It agrees quite closely with *Carpolithes Potentilloides*, Heer, as figured in Flor. Foss. Arct. II. Pl. XLIII. f. 11*b*.

Locality: clay at Kreischerville; Wm. T. Davis

f. 14. Sub rectangular in shape, about 1/8 inch by 1/16 inch, with rounded edges and angles. Thick, smooth, hard and shining.

Locality: clay at Kreischerville.

f. 15. Ovate, somewhat flattened, with rounded margins and minutely roughened surface, 1/4 inch or more long by 3/16 inch broad.

Locality: clay at Kreischerville.

The relation of the Greenland and Arctic forms to the local Cretaceous flora was commented on by N. L. Britton. F. S Lee discussing Mr. Willey's paper questioned the "testing" powers of the ascidian hypophysis. H. F. Osborn compared the development of the hypophysis in primitive urodele forms. E. B. Wilson noted the significance of these investigations with regard to the question of vertebrate descent, and indicated how they diminished the probability of descent from an annelid-like form.

A new *Callognathus* from the Cleveland shales, *C. newberryi* and a new psammodont, *Protobates quadratus*, were presented by their describer, Bashford Dean, A unique specimen of Cladodus fyleri recently added to the Columbia College Museum was exhibited and briefly commented upon.

Meeting adjourned.

December 5, 1892.

REGULAR BUSINESS MEETING.

The President, DR. HUBBARD, in the chair. About forty persons present.

The minutes of November 7th were read and approved.

The following recommendations of the Council were read:

First—The election of the following candidates—

As Fellows:

ARTHUR HOLLICK,
JAMES F. KEMP,
HENRY F. OSBORN.

As Resident Member:

C. N. Jones.

As Corresponding Member:

Robert L. Jack.

On motion, the Secretary was directed to cast a ballot electing the Fellows and Members.

The Secretary reported having cast the ballot, and the candidates were declared duly elected.

Second—The formation of a Section of Geology and Mineralogy. Approved.

Mr. Garrettson announced the generous gift of Capt. Thomas L. Casey to the Publication Fund, amounting to $500, and moved that a vote of thanks be accorded him. Carried.

Dr. Bolton presented a chart of the pronunciation and spelling of chemical terms proposed by a committee of the American Association for the Advancement of Science, 1887. This chart has been adopted by various authors, and is now published by the U. S. Bureau of Education.

The following paper was read by title:

Notes on the Clays of New York State and Their Economic Value.

BY HEINRICH RIES.

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Contents: — General remarks on the clays. Clay deposits of the Erie, Ontario, St. Lawrence and Champlain watershed. Clays of the Mohawk and Hudson River watershed. Clays of the Delaware and Susquehanna watershed. Staten Island clays. Long Island clays. Economic importance of the clays,

During the past season the writer has had occasion to visit most of the clay deposits in the State, and the following paper is intended to give a general account of some results of that work.

Deposits of clay suitable for the manufacture of brick, tile, etc., are found in nearly every county, and the introduction within the last few years of new forms of machinery and of improved methods gives every indication of future success.

Considering these deposits geologically, we find that they may be divided into three classes :

Quaternary,
Tertiary ?
Cretaceous.

The first class is by far the most common. The second class is still somewhat doubtful, but a large number of the Long Island deposits probably belong to it. (F. J. H. Merrill, Geol. of L. I., Trans. N. Y. Acad. Sci., Nov. 1884.) Of the third class there are undoubted representatives on Long Island and Staten Island, as well as some additional ones on Long Island that are questionable.

The clays of the mainland are all as far as known Quaternary. The problems of the Quaternary formations in New York are by no means solved, and it is not always possible to decide on the causes leading to the deposition of any particular body of clay by a single visit to the locality, so that this paper must be considered as a preliminary one.

A great majority of the deposits are small and basin-shaped, lying in the bottoms of the valleys. They vary in depth from four to twenty feet ; as a rule they are underlain by modified drift or by bed rock. The clay is generally of a blue color, the upper few feet being weathered mostly to a red. Stratification is mostly wanting, although streaks of marl are common. In a number of the beds small pebbles, usually of limestone, are found, and these have to be separated by special machinery in the process of brick manufacture.

These basin-shaped deposits are no doubt the sites of former ponds or lakes, formed in many instances by the damming up of the valleys, and which have been later filled up by the sediment-laden streams from the glaciers. The valleys in which these local deposits lie are usually broad and shallow. In many instances the clay is covered by a foot or so of peat.

For convenience and clearness in describing the beds of clay, the State may be divided into three divisions, exclusive of Long Island and Staten Island, which correspond pretty closely with well-marked drainage areas. Only the more important deposits under each head are mentioned.

Clays of the Erie, Ontario, St. Lawrence and Champlain Watershed.

There are several localities along Lake Erie at which clays are being worked. Chief among them is Buffalo. Around this city is an extensive series of flats underlain by a red clay, and several similar deposits occur to the north of the old shore of Lake Ontario. It is highly probable that during the former extension of the Great Lakes many of these clays were deposited. They contain in many instances limestone pebbles. A thin layer of yellow sand, suitable for tempering, often overlies the clay around Buffalo.

An extensive bed of clay of a red and grey color and horizontally stratified occurs at Watertown. It is one of the few of which an analysis has been made, and it is here given.

SiO_2	64.39
Al_2O_3	14.40
Fe_2O_3	5.00
H_2O and Org. Matter .	6.64
CaO	3.60
MgO	1.31
Alkalies	4.66
	100.00

The bank is some twenty feet thick and rests on Trenton limestone.

A deposit of considerable thickness occurs at Ogdensburgh. The clay is of a blueish color, the upper ten feet being somewhat sandy. A depth of 60 feet of clay has been proven. At places it is found to be underlain by limestone.

At Madrid, in St. Lawrence county, is a small deposit, probably the remnant of a formerly extensive one, in which the section is,

Yellow stratified sand	3 feet.
Blue clay with shells	1 foot.
Blue clay	20 feet.
Total thickness	24 feet.

The shells are probably *Mucoma fusca.*

The clay beds along Lake Champlain are estuary formations of the same age as those along the Hudson Valley. Openings have been made in them at Plattsburg, Essex, and a few other localities, but owing to the lateness of the season when I visited them information was hard to obtain.

Clays of the Mohawk and Hudson River Watershed.

Deposits of common brick clay are found at many points along the line of the New York Central Railroad from Syracuse to Schenectady. They are used at many points for the manufacture of brick and tile.

Very interesting are the Hudson River clays. They are estuary deposits and extend from Croton more or less continuously up the Hudson Valley to Glens Falls and westward to Schenectady. These clays were deposited during a post-glacial submergence which amounted to 100 feet at Croton and 340 feet at Schenectady. Upon the re-elevation of the land they were much eroded by the Hudson River.

The section involved is

Fine stratified yellow sand,
Yellow clay,
Blue clay.

They are underlain by modified drift, till or bed-rock. At the mouths of the tributary streams deltas are found. The clays are from 10 to 243 feet thick, and the blue is weathered to yellow in the upper portion of the bank. (See H. Ries, Trans. N. Y. Acad. Sci., Nov. 1891.)

Clays of the Delaware and Susquehanna Watershed.

At Breesport, near Elmira, is a bank of blue clay rising from the valley to a height of 50 feet. It was formed when the valley was dammed up. Subsequently the stream has eroded it so that now all that remains is a narrow strip which forms a sort of a terrace along the side of the valley.

A similar deposit is found at Newfield, south of Ithaca. A moraine crosses the valley a mile or two south of it.

An interesting bed of clay occurs at Levant, Chautauqua County. It occupies several acres and is probably of post-glacial age. The section as determined by artesian well borings is:

Yellow sand	4 feet.
Quicksand	4 inches.
Yellow clay	5 feet.
Blue clay	70 feet.
Hardpan	— feet.
Total thickness	83 feet.

The owner of the clay bed informed me that leaves were often found between the layers of the clay at a depth of 15 or 20 feet.

Staten Island Clays.

The clays of Staten Island are chiefly Cretaceous, as proven by the fossils found in them. (A. Hollick, Trans. N. Y. Acad. Sci., Vol. xi.) The chief outcrops are at Kreischerville, Green Ridge and Arrochar. Besides the clay there are several kaolin deposits.

In many instances the clays have been much disturbed by the passage of the ice over them, and in some cases the sections show overthrown anticlines, as on the Fingerboard Road at Clifton.

Mr. W. Kreischer informed me that the clay at Kreischerville curs in isolated masses or pockets in the yellow gravel and sands. If such is the case, and if these beds, as is usually supposed, are a continuation of the New Jersey ones, they must be explained as follows: Either the original beds have been torn apart by the ice which bore down upon them, or else by the extensive erosion of the currents which deposited the overlying sands and gravels. The writer favors this latter view.

A boring made on the site of Kreischer's fire-brick factory showed:

Sand and soil	30 feet.
Blue clay	90 feet.
White Sand	2 feet.
Sand and clay alternating . .	78 feet.
Total thickness . . .	200 feet.

Next to the church at Kreischerville is a bank of stratified sand standing some 40 feet back from the road. It appears to have been dug away considerably, but Mr. Kreischer informed me that there was once a large mass of clay at this spot, which was surrounded by the sand. To the north of this, near the shore, is a bank of blue stoneware clay overlain by four to six feet of fine yellow laminated sand, and southeast of the church is a similar bank, but the clay is of a more sandy nature. A third opening is opposite Kilmeyer's Hotel at Kreischerville, where a yellow fire-clay is dug. This is overlain by about 20 feet of sand and yellow gravel and underlain by a whitish sand. A fourth opening is situated on the shore in a bluish clay.

Borings made at various points between Kreischer's factory and Wood & Keenan's brickyard penetrated a blue clay at a depth of a few feet. This latter is no doubt of a very recent origin.

At the Anderson Brick Company's pit, near Green Ridge, the lower clay, which is of a black color, shows signs of disturbance, and slicken-sided surfaces are common. The upper portions of the bank are of blue and gray colors, and at one spot there is a thick seam of lignite. This clay is not sufficiently refractory for fire-brick. Fragmentary plant remains were found by the writer.

In the pits of the Staten Island Kaolin Company, the upper portion of the kaolin has been disturbed by the ice and the kaolin is intermixed with the till. The kaolin is here underlain by a sandy clay.

Glacial clays also occur on Staten Island, and are being used for the manufacture of brick.

Long Island Clays.

The clays are found along the north shore of the Island and in a belt through the centre, so that in describing them I have gone east along the shore and come back through the centre of the Island.

In a paper on the Geology of Long Island, read before the N. Y. Acad. Sci., in Nov. 1884, Dr. Merrill describes in detail the formations exposed on the island, and mentions the insufficiency of data necessary to afford definite conclusions concerning the sequence of geological events. Examination of the various clay-outcrops of Long Island during the past season showed that eight years had made some changes, permitting the collection of additional data and obliterating many localities described by Dr. Merrill.

On Elm Point is a bed of stoneware clay over 30 feet thick and covered with 15 to 20 feet of yellow gravel and drift. The gravel has sandstone concretions similar to those found on Staten Island, but none were found containing fossils. The clay is of a dark gray color and contains streaks of lignite in a good state of preservation. Leaves are said to have been found in this clay. It is no doubt of Cretaceous age.

There is an extensive outcrop of clay at Glen Cove, on the east shore of Hempstead Harbor. This has long been known to be Cretaceous, as proven by its contained plant remains, which are in concretions in the clay. The layers of the latter are blue and red. They are considerably tilted. Near this locality and on the shore of Mosquito Inlet is an outcroft of a pinkish clay, used for fire-brick and stoneware. Dipping under it in a northerly direction is a bed of alternating layers of quartz pebbles and clay. Associated with this is a bed of kaolin, but the exact relations of the two deposits are not known. Kaolin also crops out from under the gravels on the west shore of Hempstead Harbor. Farther up the harbor at Glenwood we find a yellowish brown clay underneath the yellow gravel.

Ferruginous sandstone concretions were found at a number of localities in the sands and gravels overlying the clays, but no fossils were found in them.

Silicified corals were discovered in the sands associated with the yellow gravel on the shore of Cold Spring Harbor.

There is a deposit of fire and pottery clay at Northport. It is of white, blue and red color and is stratified. The layers are separated by thin sheets of sand. The owner claims to have frequently dug up leaves. This is probably another Cretaceous outcrop.

The other clays along the north shore have a certain amount of similarity and are considered by Merrill to be of probable Tertiary age.

One of the most interesting clay banks is that on Fisher Island. The clay is of a reddish color similar to that on West Neck, and Centre Island, in Oyster Bay, and in its normal condition was horizontally stratified and overlain by 20 to 30 feet of stratified sand. But the whole deposit has been disturbed by the ice sheet passing over it. The layers have been ground and crumpled. On top of all is a heavy deposit of till with large boulders.

There is a rather extensive deposit of stony glacial clay between Greenport and Southold.

At West Deer Park is a clay bank of unique appearance. The section is :

	Yellow gravel	6 feet.
Containing concretions	Flesh-colored clay	2 feet.
	Red clay	1 foot.
	Black clay with pyrite	4 feet.
	Black sandy clay	4 feet.
	Red sandy clay	3 feet.
	Total thickness	20 feet.

The next time I visited this locality the section showed only a brilliant red clay on top, with the black clay underneath, and in the centre of this latter a large lenticular mass of gray sand. The black clay burns white.

About four miles below this the clay bank presents a totally different appearance.

Sand and gravel	6 feet.
Red sandy clay	6 feet.
Yellow and red sand, wavy laminations	2 feet.
Reddish yellow clay	6 feet.
Blue clay	20 feet.
Micaceous sand, cross-bedded	—
Total thickness	40 feet.

These two last-mentioned deposits are just south of the moraine.

At East Williston is a local deposit of blue sandy clay, also mentioned by Dr. Merrill. On my last visit to this locality I found a number of stems and fragments of leaves in it, although nothing sufficiently well preserved for identification.

Most of the clay beds on Long Island show signs of disturbance. In some, as at Cold Spring, overthrown anticlines have been formed. Therefore, a knowledge of the dip and strike of the beds is not always of great help.

Economic Importance of the Clays.

The economic value of the clays of New York State is becoming of more importance each year. There are about three hundred and fifty yards which manufacture building brick alone, giving an annual production of about 1,300,000,000 brick. The income from this branch of the clay industry alone amounts to about $8,500,000 annually.

In most cases the yards are situated so as to afford the greatest ease and facility of working. Along the Hudson River the clay is rarely hauled over 300 feet, and this on a down grade; the barges for transporting the brick can be brought to within a few feet of the kiln. All the Hudson River yards mold their brick by the soft-mud process; indeed, this is the one commonly used in most parts of the State.

The Hudson River yards send their product chiefly to New York City. The yards in the north and west portion of the State are usually situated on some line of railroad, and their product is chiefly locally used. In many of these we find the artificial drying of the brick to be the favorite method. They use in most cases stationary kilns.

The re-pressed brick made at Newfield are found to stand one of the highest pressures on record, viz., crushing at 240,000 pounds. The Syracuse paving brick will stand even more. These were tested on edge.

In the western portion of the State many drain-tile are made. Sewer-pipe are manufactured at several localities, the native clay being mixed with a certain proportion of Jersey fire-clay.

Roofing-tile, terra cotta and paving-brick are among the clay products of the State.

Shale is another substance which has come into use within the last few years for the making of brick. In this State the Hamilton, Chemung and Salina are being employed.

The shale is pulerized first in a dry-pan to a very fine powder and then ground with water, and in this state is plastic and can be molded into brick, etc. It very often gives better results than the clays.

Future experiments will no doubt show the availability of shales of other formations than those now used for the manufacture of clay-products.

Certain it is that we have in this State an abundant supply of clay and a still more abundant store of shales.

The Astronomical Section having organized with Prof. Rees in the chair, Dr. M. I. Pupin read a paper entitled :

The Bearing of Electrical Discharges on Solar Physics.

[ABSTRACT.]

A. Indirect evidences favoring an electrical theory of the solar corona.

1. *Evidences obtained from the visible spectrum of the corona.*—The assumption that the visible coronal glow is due to electrical disturbances in the coronal regions has just as much probability in its favor as any other assumption. That part of the coronal light which is reflected sunlight may be due to a decomposition of the coronal vapors produced by the action of the ultra-violet light of the sun, or by the action of the electrical disturbances in the coronal regions.

2. *Evidences obtained from the ultra-violet spectrum of the corona.*—These evidences seem to indicate that the maximum energy of the coronal spectrum is near its violet end. If so, this fact would speak very forcibly in favor of the assumption that the coronal light is due to electrical disturbances in the coronal regions.

B. *On the admissible causes which are capable of producing electrical disturbances in the coronal regions.*

These causes are shown to be the electrical oscillatory discharges in the solar atmosphere, resulting from the electrical tensions which are produced by the heterogeneous nature of the solar atmosphere, by internal friction and possibly also by chemical process.

C. The effects of the electrical waves propagated through interplanetary space are then discussed, especially those due to the absorption of these waves by the gases which constitute the solar corona. Various cases are considered, and it is pointed out that all the various coronal forms can be explained in a scientifically legitimate manner by the abovementioned absorptions of the electrical waves. Lines of laboratory research capable of throwing more light upon these evidences are then discussed, and the author concludes his remarks with a promise of exhibiting very soon before the Astronomical Section some experiments which have a direct bearing upon the various questions discussed in the paper.

PROF. REES then referred briefly to the observations of Holmes' comet made at Columbia College Observatory by himself and by Mr. Jacoby and Mr. Monell. These observations will be published in the *Astronomical Journal*. He also gave an account of a shower of meteors seen by him on the 23d of November. Mr. Ewing had also seen the meteors, and Dr. Bolton had heard of them.

Addendum to the Abstract of Dr. Pupin's Paper "On the Bearing of Electrical Discharges on Solar Physics."

Among the lines of laboratory research one was especially recommended and that was the investigation of the fluorescence of perfect gases under the influence of the light of powerful electrical discharges. Dr. Pupin stated that he believed that these gases are rendered fluorescent by the action of the light of very powerful oscillatory jar discharges. [In one of his experiments, which he showed to Professors Rees and Van Amringe, of Columbia College, ten days before the reading of the paper, he thinks that he succeeded in rendering hydrogen fluorescent (with a faint bluish color) by the action of the light of exceedingly powerful jar discharges; but no conclusive evidences of the phenomenon could be obtained on account of the difficulty of excluding the direct visible light of the spark from the fluorescent light.]

December 12, 1892.

Stated Meeting.

Vice-President Dr. Allen in the chair. About forty-five persons present.

The reading of the minutes was omitted.

The Section of Geology and Mineralogy was organized, replacing the older one of Mineralogy.

The following officers of the Section were elected:

R. P. Whitfield, Chairman.
James F. Kemp, Secretary.

The following Advisory Board was appointed:

T. Egleston,
A. Hollick,
G. F. Kunz,
J. J. Stevenson.

The Biological Section then organized, PROF. H. F. OSBORN in the chair, DR. BASHFORD DEAN Secretary.

The following papers were read :

J. L. WORTMAN, "On the Mammalian Fauna of the Lower Miocene. (White River formation)."

F. M. CHAPMAN, "On the Origin of Bird Life in the West Indies."

G. S. HUNTINGTON, "Note on the Ileo-colic Junction of *Procyon lotor*."

H. F. OSBORN, "On a New Artiodactyl from the Lower Miocene."

The paper of F. S. LEE, "On the Functions of the Internal Ear," was unavoidably postponed.

PROF. OSBORN gave a brief description of the Miocene *Protoceras celer*, Marsh. Both male and female skulls of this remarkably horned artiodactyl were reported as among the recent additions to the American Museum of Natural History.

On the Ileo-colic Junction in Procyon lotor and Allied Forms.

BY GEO. S. HUNTINGTON,

Professor of Anatomy, Columbia University, New York.

In presenting some points in reference to certain forms of the ileo-colic junction in mammalia for the consideration of the Section, I desire to make my communication a preliminary note, and to report, at a later date, the results of more detailed nvestigations at present in progress.

The presence of a cæcum in some form is such a widely distributed feature of the mammalian alimentary canal as to render the absence of this structure a fact of considerable morphological interest.

More especially does this become the case if we leave out of consideration the orders of Insectivora and Chiroptera, in which the absence of the cæcum is characteristic, and confine our attention to the isolated instances of lack of this structure in other groups. Narrowed down to these limits the absence of a distinct cæcum is noted in several Cetaceans, *Physeter macrocephalus, Delphinus delphis, Monodon monoceros ;* further, in the carnivorous marsupial *Dasyurus*, in the single instance of *Myoxus* among Rodentia, in certain Edentates, Tardigrada and Manidæ, and notably in certain members of the carnivorous groups of Arctoidea.

In taking a general view of the Carnivora, it appears that in respect to the structure of this portion of the alimentary tract, as well as in reference to other features, the Cynoidea, including the dogs, the wolves, jackals and foxes, form a well-marked central group, with highly developed and convoluted cæca, from which on the one hand the Ailuroidea, including cats, civets and hyenas, depart, with cæcum uniformly present, but short and markedly pointed at the termination, suggesting the degeneration of a formerly more developed structure, while on the other the Arctoidea, bears, weasels and raccoons, constitute a series bound together by many common fundamental peculiarities of structure, and presenting in many members of the group a complete or nearly complete absence of a cæcal appendage. In the typical Ursidæ the absence of the cæcum appears to be the rule.

Among the Procyonidæ, *Nasua* has long been known to present the same peculiarity. The addition of *Procyon lotor* to the list of forms devoid of a cæcum has, to my knowledge, not been made before, although the close relations existing in other respects between the subfamilies of Procyoninæ and Nasuinæ would render the agreement in this particular not unexpected.

As regards the remaining families of Cercoleptidæ and Ailuridæ, no data are at hand.

In the group of musteliform Arctoidea the absence of the cæcum in *Mustela* has been noted. It is among the subfamilies of the Mustelæ that further investigations should reveal interesting forms, for here in other respects deviations from the Arctoidean type are met with, as the transition from the plantigrade *Galictis* to the subplantigrade *Gulo* and the completely digitigrade weasels and martens.

Surely, the general impression gained from a bird's-eye view of the mammalian alimentary canal, which would assign to herbivora a complicated cæcal apparatus, and reduce the same to the simpler forms in Carnivora, must become modified when considering the marked exceptions prevailing in the group under discussion, where with a combination of frugivorous and carnivorous habits, the ileo-colon presents this complete reduction, nor could we desire a better illustration of the truth that other factors besides use influence and determine structural peculiarities. The persistence of a primitive ancestral type in one, and successive modifications of the same in other directions, can alone explain such conditions as the identity of the dentition in Cynoidea and Arctoidea, whereas in another part of the same organic system we meet with the transition from the comparatively highly developed and complicated cæcum of the former to the simple ileo-colic junction of the latter. In respect to specific peculiarities of the condition as found in *Procyon lotor*, a few facts deserve mention.

The transition from large to small intestine is marked by a difference in the calibre as well as in the structure of the wall of the tube. For a distance of about 15cm. before the ileo-colic junction is reached, the distal portion of the ileum presents a series of irregularities in calibre. A number (2-3) of constrictions at a few cm. interval occupy this terminal portion. They are associated with an increase in the circular muscular fibres of the gut, which appear somewhat aggregated in these situations, but the narrowing of the lumen remains after complete relaxation and distension of the intestine.

It appears reasonable to bring this condition into relation with the complete absence of an ileo-colic valve. Some form of mechanical separation of the lumen of the canal between large and small intestine seems to belong to forms in which there is an absence of cæcum and ileo-colic valve.

In *Manis macrura* this appears to be accomplished by the abrupt bend of the tube at the point of transition and may serve to render a return of contents from large to small intestine more difficult.

In *Procyon* the constrictions and the accompanying muscular arrangements in the terminal part of the small intestine may perform the same function. As regards the colon, a thicker circular band of muscular fibres at the ileo-colic junction itself, undoubtedly acts in the same way, although it does not impress itself on the lumen of the canal as a permanent fold in the relaxed and distended condition.

An increased bearing of the convex margin of the large intestine may fairly be taken to represent the cæcal disposition.

Several lines of investigation appear to promise results in this connection.

The embryological differentiation of large and small intestine in Procyonidæ may afford valuable information. It seems probable that the ileo-colic junction in this form represents the highest grade of the process of reduction and diminution observed in so many instances, that of our own cæcum and vermiform appendix being the most marked.

If such is the case the early stages of development should give indications of the previous primitive form.

We are at present making arrangements for obtaining a series of *Procyon* embryos for this purpose.

Again, a careful and critical comparison of the entire alimentary system of various forms devoid of cæcum taken from different groups may point to some common structural features in other parts of the system which will aid in affording an explanation of the condition. This would of course include a histological examination of the digestive tract.

The minutes of November 21st and 28th omitted in regular order are here given in full.

November 21, 1892.

Stated Meeting.

The President, Dr. Hubbard, in the chair ; about seventy-five persons present.

The reading of the minutes was omitted.

Prof. Henry F. Osborn, of Columbia College, delivered the second lecture of the Public Course on:

"The Rise of the Mammalia," illustrated by specimens and lantern slides.

November 28, 1892.

Stated Meeting.

Mr. Tatlock in the chair ; six persons present.

The minutes of October 31st and November 21st were read and approved.

Robert L. Jack, of Brisbane, Queensland, was nominated as as Corresponding Member.

The following paper was read :

A New Form of Condenser for Water Analysis and a Compact Distilling Apparatus.

BY FRANCIS P. SMITH.

A compact form of distillation apparatus had for some time past seemed to me a desirable thing, and when the desirability presented itself in the form of a necessity, my ideas took the definite shape that I shall present to you this evening.

The first ready-made object to which I objected was the long and cumbersome Liebig condenser, which, when placed in an inclined position and connected to a retort, usually occupies a space of somewhat more than a yard in length. Besides this, the connection between a retort neck and a condenser is frequestly a very unsatisfactory one.

My first step was to secure a piece of block tin pipe 3-16 of an inch in diameter and about twenty inches long. One end was cut off square by means of a jack-knife, and the other slanting, so as to facilitate the dropping of the condensed liquid. I mention the means employed because in this way it is possible to make a perfectly clean and even cut, with no burr such as a saw would leave. The pipe is next twisted around a circular rod about 1-2 an inch thick in a regular spiral, beginning four inches from one end and ending the same distance from the other. By this means it is possible to produce at small cost an excellent spiral block tin condenser, which may be used for a variety of purposes. A tube for containing the water may be made of a piece of glass tubing of sufficient diameter, closed at each end by a rubber stopper provided with two holes, one for the exit or inlet tube and the other for the block tin pipe. When in use for a water analysis or Kjeldahl distillation it is conveniently set up in a vertical position, attached to a large iron tripod by a clamp, and the generating flask is fastened to the same support by a similar clamp.

A feature in this connection is the employment of a so-called evaporating burner for heating the liquid to be distilled. Playing upon the bottom of an Erlenmeyer flask this gives a number of heated points from which the bubbles seem to rise readily, and even strongly alkaline solutions boil easily and without any of the characteristic bumping usually so annoying. The flames should be about half an inch high and should come nearly the same distance from the bottom of the flask. The Wurtz tube is added as an additional safeguard against bumping.

The mounting of the entire apparatus upon one stand gives great facility in moving it about and makes the adjustment of the connections easier than it would otherwise be.

Dr. H. T. Vulté exhibited and explained a modified form of apparatus for the determination of Glycerol, by Planchon's Method.

December 19, 1892.

STATED MEETING.

The President, DR. HUBBARD, in the chair. About one hundred persons present.

The reading of the minutes was omitted.

Prof. W. B. SCOTT, of Princeton, delivered an illustrated lecture on "Fossil Hunting in the Northwest."

At the close of the lecture a vote of thanks was accorded Prof. SCOTT, and the meeting adjourned to January 9, 1893.

January 9, 1893.

REGULAR BUSINESS MEETING.

Vice-President DR. BOLTON in the chair. About forty persons present.

The minutes of December 5, 1892, were read and approved.

The following recommendation of the Council was read :

The change of name of the Astronomical Section to the Section of Astronomy and Physics. Approved.

SECTION OF ASTRONOMY AND PHYSICS.

The Section was called to order at 8:15 P. M., Professor REES in the chair.

A paper was read by MR. JACOBY on :

The Parallaxes of μ and θ Cassiopeiæ, Deduced From Rutherford Photographic Measures.

The results obtained are as follows :

Parallax of μ Cassiopeiæ $= 0.''275 \pm 0.''024$
Parallax of θ Cassiopeiæ $= 0.''232 \pm 0.''067$

The paper will appear in the Annals of the Academy.

Prof. REES made a few remarks on the above paper, after which Prof. GEORGE E. HALE, of the University of Chicago described some of his recent investigations in solar physics. Prof. Hale exhibited lantern slides of the apparatus used by him at the Kenwood Observatory, and some very remarkable photographs of prominences and faculæ which he has obtained in full sunshine.

BIOLOGICAL SECTION.

Prof. OSBORN in the chair.

The following papers were presented :

A. A. JULIEN—"Suggestions in Microscopical Technique," including :

(A) A carrier of cover impressions (mycoderm blood), utilizing as clamps a coil of brass wire mounted in a phial. The same device, with a platinum coil, serves as a convenient staining phial for cover glass preparations.

(B) A suggested medium for mounting delicately contractile protoplasmic objects.

(C) Devices for avoiding inclusion of air-bubbles in mounts.

(D) Balsam-paraffine as a ring varnish.

O. S. STRONG—"On the components of cranial nerves of Amphibia." In the seventh a dorsal root was shown to pass off into a branch representing Ophthalmicus superficialis facialis and Buccalis of Fishes, and innervating the lateral sense organs of the head. In vagus a root of similar internal origin passes into the R. lateralis innervating the lateral sense organs of the body. Another component of the facialis is the fasciculus communis of Osborn, which was believed to represent the lobus vagi of fishes. This passes off into the palatinus and mandibularis internus, innervating the mucous epithelium of the oral cavity; while in the glosso-pharyngus and vagus similar components derived from this fasciculus innervate in like manner portions of the alimentary canal and its appendages. The relation of the results to segmentation of head was discussed.

THE NORTH AMERICAN SPECIES OF THE GENUS LESPEDEZA.

BY N. L. BRITTON.

About ten years ago I was lead to observe the species of *Lespedeza* growing in the vicinity of New York by failing to identify certain forms from the descriptions at my command in the botanical text books. Dr. Watson's "Bibliographical Index" had then recently been published, and the hints there given gave me a great deal of light on the question, but still the species and varieties there accepted were not wholly satisfactory, and as I thought I detected some errors I determined to accumulate specimens, in order to endeavor to determine by long series of the various forms and a study of their geographical distribution, which of them were entitled to specific rank and which were mere conditions of development. Nearly all the forms that I have been able to recognize in the great number of specimens now contained in the Columbia College Herbarium, and the other herbaria which I have consulted * have been named by one author or another, as species or varieties. I have endeavored to ascertain by an inspection of the types employed by these authors for their descriptions, which names

* Those in the National Herbarium, that of the Academy of Natural Sciences of Philadelphia, Harvard University, the Royal Botanic Gardens at Kew, the British Museum of Natural History, the Musée d' Histoire Naturelle at Paris, the Boissier and De Candolle Herbaria at Geneva, the Herbaria of Capt. John Donnell Smith, Prof. T. C. Porter, Hon. Addison Brown, and Dr. Wm. E. Wheelock.

are the oldest available for the various forms, and have succeeded in seeing most of the type specimens which would influence the result. I have adopted the earliest available name in all cases, discarding such as have originally been applied to different species than those with which they have been associated by some authors, on the principle that a name once published for an organism belongs to it and to no other.

Michaux, who founded the genus * recognized four species, all North American, viz: 1, *L. sessiliflora,* based on *Medicago Virginica,* L.; 2, *L. procumbens*; 3, *L. capitata,* and 4, *L. polystachya,* based on *Hedysarum hirtum,* L.

Persoon, four years later, † accepted all of these except *L. sessiliflora,* which he redescribed as *L. reticulata,* basing it on *Hedysarum reticulatum,* Willd., admitted *Hedysarum violaceum,* L. into the genus as *L. violacea,* and added five Asiatic species, together with one of whose habitat he was uninformed Pursh, in 1814, maintained eight species, all of which are accepted in the following pages, although mainly under older names. Nuttall, in 1818, admitted eight, suppressing one of Pursh's and adding *L. Stuvei.* Torrey and Gray in, 1840, reduced the number to six, recognizing, however, a large number of varieties. The genus was monographed by Maximowicz ‡ in 1873, who described 33 species, six of them North American, following very closely the treatment of Torrey and Gray. Dr. Watson's Bibliographical Index of 1878 admits nine species, including the introduced *L. striata,* and in the sixth edition of Gray's Manual he recognizes the same number. I am confident that the difficulties found in naming these plants from descriptions are on account of too few species being admitted. It seems to me that there are twelve distinct species in eastern North America with a possibility of one or two more claiming recognition when more specimens of them are obtained.

As to the characters which I have mainly relied upon to determine species, I have not been able to detect a better wherewith to effect a primary division of our native ones than the short calyx lobes—shorter than the pod—taken with the presence of cleistogamous flowers and nearly always purple or pink corollas for one group, and the long calyx-lobes taken with white or ochroleucous corollas (sometime tinged with purple) and absence of cleistogamous flowers for the other. The peduncled or sessile clusters of flowers, shape of the leaves, erect

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* Flor. Bor. Am. ii. 70.

† Syn. ii. 318.

‡ Act. Hort. Petrop. ii 327-388.

or trailing habit, character and amount of pubescence, and, very important, the geographical distribution of the various forms appear to me to satisfactorily segregate the species.

Perennials; stipules and bracts subulate; calyx-lobes narrow.	
Both petaliferous and apetalous flowers present; corolla usually purple or pink, pod exserted.	
Peduncles slender, mostly exceeding the leaves.	
Petaliferous flowers capitate or spicate.	
Plants trailing or diffusely procumbent.	
Glabrous or appressed-pubescent.	1. L. repens.
Woolly or downy pubescent.	2. L. procumbens.
Plants erect, rather stout, pubescent.	3. L. Nuttallii.
Petaliferous flowers loosely paniculate.	4. L. violacea.
Flower-clusters of both kinds sessile or nearly so	
Leaves oval, oblong or orbicular.	
Foliage densely downy-pubescent.	5. L. Stuvei.
Foliage glabrate or appressed-pubescent.	6. L. intermedia.
Leaves linear or linear-oblong.	7. L. Virginica.
Flowers all complete; corolla whitish or yellowish; pod included, or scarcely exserted.	
Leaves oblong, ovate-oblong or nearly orbicular.	
Peduncles exceeding the leaves.	8. L. hirta.
Peduncles shorter than the leaves.	9. L. capitata.
Leaves linear or linear-oblong; peduncles elongated.	
Spikes capitate, densely-flowered	10. L. angustifolia.
Spikes interrupted, loosely-flowered.	11. L. leptostachya.
Annual; stipules ovate; calyx-lobes broad.	12. L. striata.

1. Lespedeza repens (L.) Bart.

Hedysarum repens, L. Sp. Pl. 749 (1753).

Lespedeza repens, Bart. Prodr. Fl. Phil. ii. 77 (1817) in part.

Trailing or diffusely procumbent, glabrate or sparingly appressed-pubescent, tufted, stems slender, simple or somewhat branched, 6′—24′ long. Petioles shorter than the leaves; stipules subulate, about 1″ long; leaflets oval, oblong or obovate, obtuse or retuse at the apex, narrowed or rounded at the base, 3″—8″ long; peduncles of the petaliferous flower-clusters slender, much exceeding the leaves; inflorescence capitate, rather loose; corolla purple, 2″—3″ long; pod oval-orbicular, acute, finely pubescent, 1½″ long.

In dry or sandy soil, Long Island to Florida, west to West Virginia, Minnesota, and Texas.

The species is based on the "Hedysarum caulibus procumbentibus, racemis lateralibus solitariis, petiolis pedunculo longioribus" of Gronovius Fl. Virg. p. 86. There is a specimen with this label in the herbarium of the British Museum of Natural History, the label bearing in addition the following:

"A species of trailing Trefoil with purple and white flowers, two or three on each footstalk, coming forth from the wings of the leaves. D. Clayton ex Virginia, num. 85."

"Hedysarum procumbens, Trifolii fragiferi folio. H. Elth. p. 172, tab. 172, fig. 169." [This is erroneous. The plant of plate 172, Hortus Elthamensis, as shown by the figure, is not a *Lespedeza*, but apparently a species of *Desmodium*. It is said to have been raised from seeds from Ceylon.]

Also in another handwriting, apparently written later: "Hedysarum foliis ternatis obcordatis, caulibus procumbentibus, racemis lateralibus. Linn. Syst. Gen. 793, n. 24. Sp. Pl. 2, p. 1056, n. 30." [This is Linnæus' description of the species in Sp. Pl. Ed. 1, p. 749 and Ed. 2, p. 1056.]

The plant of Linnæus herbarium marked *Hedysarum repens* is not a *Lespedeza* at all. Smith has noted on the sheet "planta Dill. Elth.," but I think he was mistaken. I did not recognize it. But the Gronovian specimen preserved at the British Museum of Natural History is certainly our plant, and the type of the species.

It may readily be distinguished from *L. procumbens* by its very slender, nearly glabrous stems, its equally glabrous leaves, which have a strong tendency to be obovate, and are commonly retuse or emarginate at the apex, sometimes almost obcordate. It seems to be of more southern range than *L. procumbens*, but more specimens are needed to establish its geographical distribution. Its pod is usually shorter, more pubescent and less prominently reticulated than that of *L. procumbens*.

2. LESPEDEZA PROCUMBENS, MICHX.

Lespedeza procumbens, Michx. Fl. Bor. Am. ii. 70 (1803).

Woolly or downy-pubescent, trailing, procumbent or sometimes ascending, stouter than the preceding species, stems 12′—30′ long. Stipules subulate; petioles commonly much shorter than the leaves; leaflets oval or elliptic, rarely slightly obovate, obtuse or retuse at the apex, rounded at the base, 5″—12″ long; peduncles of the petaliferous flower-clusters longer than the leaves, or sometimes wanting and the flowers all apetalous and nearly sessile ; pods oval-orbicular, acute, pubescent, 1½″ long.

In dry soil, Massachusetts to Florida, west to Missouri, Arkansas and Louisiana.

The type is preserved in Michaux's herbarium at Paris. The plant is always conspicuously pubescent. The leaves are larger than those of *L. repens*, rarely showing any tendency to the obovate form and never approaching the obcordate in any specimens that I have seen. It is much commoner in southern New York and New Jersey than *L. repens*.

There is a fruiting specimen of a *Lespedeza* in Herb. Gray, collected by Chas. Wright in Texas, which I refer here with considerable hesitation.

Mr. Edwin Faxon has collected specimens at Muddy Pond Hills, Mass., which differ from the typical plant in their declinate but not prostrate stems and narrow leaflets.

3. Lespedeza Nuttallii, Darl.

Lespedeza Nuttallii, Darl. Fl. Cestr. Ed. 2, 420 (1837).

Lespedeza virgata, Nutt. in T. & G. Fl. N. A. i. 368 (1840) not D. C.

Erect, simple or slightly branched, more or less villous-pubescent, 2°—3° high. Stipules subulate; petioles shorter than the leaves ; leaflets oval, obovate or suborbicular, thickish, obtuse or emarginate at the apex, narrowed or sometimes rounded at the base, dark green and glabrous or nearly so above, villous-pubescent beneath, 4″—20″ long, 3″—10″ wide; peduncles slender, usually exceeding the leaves; inflorescence capitate, dense ; flowers purple or pink, about 3″ long ; pod oblong, acuminate or acute at each end, very pubescent, 2½″—3″ long, sometimes only slightly exceeding the calyx-lobes.

Dry soil, Southern New England and New York to Pennsylvania, Michigan, Kansas and Alabama.

Authentic specimen in the Herbarium of the Philadelphia Academy of Natural Sciences. The species was treated by Torrey and Gray as a variety of *L. Stuvei* and this view was accepted by Darlington in the third edition of the Flora Cestrica. In my view it is abundantly distinct, being much less pubescent, having slender-peduncled heads of flowers, much longer calyx-lobes, and longer, strongly acuminate pods.

4. LESPEDEZA VIOLACEA (L.) PERS.

Hedysarum violaceum, L. Sp. Pl. 749 (1753).

Lespedeza violacea, Pers. Syn. ii. 318 (1807).

Erect or ascending, sparingly pubescent, usually much branched, 1°—3° high. Stipules subulate, 2″—3″ long; petioles shorter than or equalling the leaves; leaflets oval, elliptic or broadly oblong, thin, obtuse or retuse at the apex, rounded at the base, 6″—2′ long, appressed-pubescent beneath; peduncles, at least the upper ones, longer than the leaves; inflorescence loose, paniculate; corolla purple, 3″—4″ long; pod ovate or oval, acute, finely and sparingly pubescent, 2″—3″ long.

In dry soil, New England to Florida, west to Minnesota, Kansas, Louisiana, and Northern Mexico.

This is based on "Hedysarum foliis ternatis, lanceolatis, leguminibus monospermis" of Gronovius Fl. Virg. 87. The specimen so labelled in the herbarium of the British Museum, while checked off in the copy of the Flora Virginica of that institution, so that unless recently lost, must be somewhere in the collection, could not be turned up at the time of my visit in 1891, so I am not quite certain that I correctly understand it, although Linnæus' supplementary description in Sp. Pl. 749 appears to point to the plant, at least in part. In the Linnæan herbarium, three sheets are included in *violacea.* (I) A sheet bearing two good fruiting specimens from Kalm of what I call *L. intermedia.* (II) A sheet bearing fruiting specimens of *L. repens* and *L. procumbens,* besides a specimen of *Desmodium paniculatum.* (III) A sheet not marked by Linnæus bearing two specimens of the plant here accepted as *violacea,* annotated by Smith "*divergens*, Ms. B." So as illustrated by his own herbarium the species is complex, but the specimens are not the types of the species.

It is sometimes troublesome to distinguish between this species and *L. repens.* The erect habit, larger leaves which scarcely show any tendency towards the obovate form and the branching inflorescence with few-flowered clusters, the larger, longer and less pubescent pod are characters, which, when taken together, will always mark it as distinct. Barton appears from the few specimens preserved illustrating his Prodromus of the Flora of Philadelphia to have confounded the two. I have not seen Persoon's specimens, but his description points satisfactorily to the plant understood by me as *violacea.*

5. Lespedeza Stuvei, Nutt.

Lespedeza Stuvei, Nutt. Gen. ii. 107 (1818).

Erect or ascending, simple and wand-like or sometimes slightly branched, densely velvety or downy-pubescent all over, 2°—4° high. Stipules subulate, 2″—3″ long; petioles commonly much shorter than the leaves; leaflets oval, oblong or suborbicular, obtuse or retuse at the apex, narrowed or rounded at the base, 6″—10″ or rarely 15″ long; flowers of both kinds in nearly sessile, axillary clusters; corolla purple, 2″—3″ long; pod ovate-oblong, acute, 2″—3″ long, downy-pubescent.

Dry soil, Long Island [Wheelock] to Virginia, west to Michigan, and Missouri.

The species is represented among the Gronovian plants at the British Museum by a specimen from Clayton with the following label: "Medicago caule erecto, vix ramoso, racemo dense spicato terminato, Gron. Fl. Virg. 86." It does not seem to have been taken up by Linnæus.

Var. angustifolia, n. var.

Leaves linear or linear-oblong, obtuse, mucronulate.

New Jersey and Southern Pennsylvania to North Carolina, Missouri and Texas.

Both the species and the variety have the habit of developing pubescent hard obliquely ovoid bodies 1″—2″ long at the bases of some of the leaves; these I take to be abortive branches. I have observed them on *L. reticulata* as well.

It is possible that further collection and study of these two forms may afford characters sufficient for the recognition of the variety here proposed as a species. It has been suggested that *Stuvei* is a hybrid between *violacea* and *hirta,* but I see no probability of this being true.

6. Lespedeza intermedia (S. Wats).

L. reticulata, S. Wats. Bibliog. Index, 233 (1878) not Pers.

L. Stuvei, var. *intermedia,* S. Wats., in A. Gray, Man. Ed. 6, 147 (1889).

Hedysarum frutescens, L. Sp. Pl. 748 (1753), not *Lespedeza frutescens,* Ell. Sketch Bot. S. C., ii., 206 (1824).

Erect, simple or branched, finely appressed-pubescent or glabrate, 1°—3° high. Stipules subulate, 2″—3″ long; petioles equalling or shorter than the leaves; leaflets oval, oblong or elliptic, obtuse, truncate or retuse at the apex, narrowed or rounded at the base, 6″—18″ long, glabrous and dark green above, paler and pubescent beneath; flowers of both kinds in nearly sessile, axillary clusters, generally crowded towards the summit of the stem; corolla purple, 2″—3″ long; pod ovate-oblong, acute or mucronate, pubescent, about 2″ long.

Dry soil, Ontario and New England to Michigan, south to Florida, Illinois, Arkansas, and Texas.

I have to disagree with Dr. Sereno Watson as to the alliance of this plant with *L. Stuvei.* If reducable to a variety at all, a position which is not here accepted, it is more nearly related to *L. Virginica.* I have not been able to associate any available name with the species older than the one given it by Dr. Watson. The Linnæan *Hedysarum frutescens* is clearly the same plant, as illustrated by the Gronovian specimen on which it is based in the herbarium of the British Museum, bearing the following label, which is the name cited by Linnæus: "Hedysarum foliis ternatis subovatis, caule frutescente, Gron. Fl. Virg. 174." In Dr. Watson's Bibliographical Index, p 233, *Hedysarum reticulatum* of Willd. Sp. Pl. iii. 1194 is cited as an equivalent of both this form and the following species, from which I distinguish it primarily by its broader leaves, and while the geographical distribution of the two appears to be substantially the same I have not seen them growing in very close proximity.

Forms occur with flowers all petaliferous, others with all apetalous and others bearing various proportions of both kinds.

7. LESPEDEZA VIRGINICA (L.).

Medicago Virginica, L. Sp. Pl. 778 (1753).

Hedysarum reticulatum, Muhl. in Willd. Sp. Pl. iii. 1194 (1803).

Lespedeza sessiliflora, Michx. Fl. Bor. Am. ii. 70 (1803).

Lespedeza reticulata, Pers. Syn. ii. 318 (1807).

L. violacea, var. *angustifolia,* T. & G. Fl. N. A. i. 367 (1840).

Hedysarum junceum, Walt. Fl. Car. 185 (1788) not L.

Erect, slender, simple and wand-like or branched, resembling the preceding species. Leaflets linear or oblong-linear, 6″—18″ long, 1″—2½″ wide, truncate, obtuse or sometimes acute at the apex, finely pubescent or glabrate on both surfaces; clusters of both kinds of flowers sessile, crowded in the upper axils; pod ovate, acute, 2″ long, pubescent or nearly glabrous.

Dry soil, Massachusetts to Minnesota, south to Florida, and Texas.

This is based on "Medicago caule erecto ramosissimo, floribus fasciculatus terminalibus," Gron. Fl. Virg. 86. This type is preserved in the herbarium of the British Museum of Natural History. Linnæus cites as a synonym "Loto affinis trifoliata frutescens glabra, Pluk. Mant. 120," but the specimen of this preserved among Plukenet's plants, also at the British Museum of Natural History, is *L. capitata*, Michx.

The type of *Hedysarum reticulatum* is a plant sent by Muhlenberg to Willdenow. I have not seen it, but it was evidently seen by either Dr. Torrey or Dr. Gray as the reference to Willdenow's name in the Flora of North America is followed by an exclamation mark.

Lespedeza sessiliflora, Michx. is preserved in Herb. Michaux. Persoon's *L. reticulata* I have not seen, but his description is satisfactory. *Hedysarum junceum*, Walt. is not preserved in Walter's Herbarium at the British Museum of Natural History. The calyx teeth of the petaliferous flowers of this species are quite long, sometimes equalling the pod.

8. Lespedeza hirta (L.) Ell.

Hedysarum hirtum, L. Sp. Pl. 748 (1753).

Lespedeza polystachya, Michx. Fl. Bor. Amer. ii. 71 (1803).

Lespedeza hirta, Ell. Sketch Bot. S. C. ii. 207 (1824).

Erect or ascending, rather stout, generally branching above, villous or silky-pubescent, 2°—4° high. Stipules subulate, 1″—2½″ long; petioles shorter than the leaves; leaflets oval or suborbicular, obtuse at each end, sometimes emarginate at the apex, 6″—2′ long; peduncles elongated, usually much exceeding the leaves; heads oblong, rather dense, ½′—1½′ long; flowers all complete; corolla yellowish-white or the standard purple spotted, about 3″ long; pod oblong, acute, very pubescent, about equalling or slightly exceeding the calyx-lobes.

Dry soil, Ontario to Florida, west to Illinois, Minnesota, and Louisiana.

This is one of the most strongly marked and easily recognizable species. It is based on "Trifolium fruticosum hirsutum, spicis oblongis pedunculatis," Gronov. Fl. Virg. 173. There is a specimen of it from Kalm in the Linnæan herbarium.

L. polystachya, Michx. is preserved in Herb. Michaux, and it appears from the description to be the plant of Elliott. The var. *sparsiflora*, T. & G. Fl. N. A. i. 368, is a slender, more glabrous plant, with loosely-flowered spikes collected by Dr. Torrey at Bloomingdale, N. Y., and preserved in his herbarium; and is hardly worthy of recognition as distinct.

VAR. OBLONGIFOLIA, n. var.

Leaves oblong, obtuse at each end, 9″—15″ long, 2″—4″ wide, glabrate above, appressed-pubescent below; peduncles slender; spikes looser, 1′—1½′ long; calyx very pubescent, exceeding the densely pubescent pod. Pine barrens, Egg Harbor, N. J., [J. Bernard Brinton].

This is a very well-marked form. There are four sheets of it in the Paris Herbarium, two of them from Le Conte, one from Lindley, and one from Torrey, although no specimen of it was preserved in Dr. Torrey's herbarium. There is an old New Jersey specimen in the Gray Herbarium. I place it as a variety of *L. hirta* on account of its long peduncles.

9. LESPEDEZA CAPITATA, MICHX.

Hedysarum frutescens, Willd. Sp. Pl. iii. 1193 (1803) not L.

Lespedeza capitata, Michx. Fl. Bor. Am. ii. 71 (1803).

Lespedeza frutescens, Ell. Sketch Bot. S. C. ii. 206 (1824).

Hedysarum umbellulatum, Walt. Fl. Car. 184 (1788) not L.

Stiff, erect or ascending, mainly simple and wand-like, silky or silvery pubescent, 2°—4° high. Stipules subulate; leaves nearly sessile; leaflets oblong or oval, obtuse or acute at each end, 1′—1½′ long, 3″—5″ wide; peduncles much shorter than the leaves, or the dense, globose-oblong, heads sessile in the upper axils; flowers all complete; corolla yellowish-white, with a purple spot on the standard, about 3″ long; pod ovate-oblong, very pubescent, about one-half as long as the calyx-lobes.

Dry fields, Ontario and Vermont to Florida, west to Minnesota, Nebraska, and Louisiana.

The type specimens are in Michaux's herbarium at Paris, but the sheet on which they are mounted has a number of specimens of *L. angustifolia* glued down on it as well. *Hedysarum frutescens*, Willd., is authenticated as this species by Torrey and Gray. In my Catalogue of the Plants of New Jersey I used the name *L. frutescens*, but it is not available, Willdenow's *frutescens* not being the same as the original *frutescens* of Linnæus.

VAR. LONGIFOLIA (D.C.) T. & G.

Lespedeza longifolia, D.C. Prodr. ii. 349 (1825).

L. capitata, var. *longifolia*, T. & G. Fl. N. A. i. 368 (1840).

Leaflets linear-lanceolate or linear-oblong, sometimes 4′ long. Illinois and Missouri.

The specimen in the Candollean herbarium is from "Louisiana, ex herb. Bonjean." The other specimens which I have seen are from Illinois (Short), Beardstown, Ill. (Geyer), Missouri (Eggert). The var. *sericea*, Hook, and Arn. Comp. Bot. Mag. i. 23, maintained by Torrey and Gray, Maximowicz and Watson, appears to me only as a very silvery pubescent state of the species, which is almost always silvery to some extent.

10. LESPEDEZA ANGUSTIFOLIA (PURSH) ELL.

L. capitata, var. *angustifolia*, Pursh, Fl. Amer. Sept. 480 (1814).

Lespedeza angustifolia, Ell. Sketch Bot. S. C. ii. 206 (1824).

L. hirta, var. *angustifolia*, Maxim. Act. Hort. Petr. ii. 379 (1873).

Erect, simple or branched above, slender, appressed-pubescent, 2°—3° high. Stipules subulate ; leaves nearly sessile ; leaflets linear or oblong-linear, rarely some of the lower ones lance-linear, 1′—1½′ long, 1″—2″ wide, obtuse, truncate or acutish at the apex ; peduncles elongated, usually exceeding the leaves ; flowers nearly as in the preceding species ; pod ovate-orbicular, slightly shorter than the calyx-lobes.

Dry, sandy soil. Plymouth, Mass. [Oakes, E. Faxon], Long Island, south to Florida, west to Michigan and Louisiana.

I have not been able to find Pursh's type, although it is authenticated by Torrey and Gray and Maximowicz cites a specimen collected by Pursh. The species is very clearly defined.

I have specimens of a peculiarly short-leaved form of this plant from Florida, communicated by Dr. Chapman, which may claim recognition as var. BREVIFOLIA.

11. LESPEDEZA LEPTOSTACHYA, ENGELM.

Lespedeza lepostachya, Engelm. in A. Gray, Proc. Am. Ac. xii. 57 (1876).

Erect, simple or branched, 1°—3° high, silvery-pubescent with appressed hairs. Stipules subulate ; petioles shorter than the leaves ; leaflets linear, 1′—1½′ long, 1″—2″ wide ; spikes slender, interrupted and loosely-flowered, on peduncles equalling or exceeding the leaves ; corolla as in the preceding species ; flowers all complete ; pod ovate, pubescent, about 1½″ long, nearly equalling the calyx.

Prairies, Illinois to Iowa, Wisconsin and Minnesota.

This most distinct of all our species appears to be rather rare and local. The specimens which I have seen are from Fountaindale, Ill. (Bebb), Emmet Co., Iowa (Cratty).

12. LESPEDEZA STRIATA (THUNB.) H. & A.

Hedysarum striatum, Thunb. Fl. Jap. 289 (1784).

Lespedeza striata, H. & A. Bot. Beechey, 262 (1841).

Annual, diffuse or ascending, branched, tufted, sparingly appressed-pubescent, 6′—12′ long. Stipules ovate, acute or acuminate, 1″—2″ long; petioles much shorter than the leaves; leaflets oblong or oblong-obovate, 4″—9″ long, 1″—4″ wide, obtuse at the apex, narrowed at the base, their margins usually sparingly ciliate ; flowers 1 to 3 together, sessile or nearly so in the axils, both petaliferous and apetalous ; corolla pink or purple, about ½″ long ; calyx-lobes ovate ; pod oval, acute, slightly exceeding the calyx-lobes.

In fields, Virginia [Canby, Hollick, Porter, Brinton], Illinois [J. Schneck], West Virginia [Millspaugh], Missouri, and very common in the Southern States. Naturalized from eastern Asia.

January 16, 1893.

STATED MEETING.

One hundred persons present.

In the absence of the president Mr. GARRETTSON presided and introduced Prof. CHARLES R. CROSS, of the Massachusetts Institute of Technology, who delivered an illustrated lecture on "The Determination and Recent History of Musical Pitch, especially in this Country."

At the close of the discourse a vote of thanks was tendered the lecturer.

January 23, 1893.

STATED MEETING.

SECTION OF GEOLOGY AND MINERALOGY.

The Section was called to order by the Chairman, Prof. WHITFIELD, at 8:10 P. M., with fifteen members present.

The following papers were read:

Dr. J. L. WORTMAN, "The Relationship of the Puerco Beds to the Laramie."

The speaker described the interesting faunal and physical relations of the two, basing his remarks on personal observations in northwestern New Mexico, and in Wyoming. The paper was discussed by Professors KEMP, WHITFIELD, and others.

Professor A. J. MOSES, "Rare Faces on Pyrite Crystals, from the Kingsbridge Ship Canal," and upon "An apparently new Sulphate from Arizona."

The pyrite crystals were associated with muscovite and quartz in a cavity in a limestone block that was quarried from the eastern end of the ship canal. They rarely exceeded $\frac{1}{4}$ inch in longest dimension, and were octahedra modified by cube, pyritohedron, i-2, and diploid $3\text{-}\frac{3}{2}$. Faces of the tetragonal trisoctahedron 2–2 were observed and determined on a few individuals. Instead of the ordinary striations parallel to intersections of the cube and pyritohedron, these crystals have others on the faces of the octahedron, diploid and pyritohedron and parallel to the intersections of these with one another. The octahedral faces also show striations parallel to their intersections with the cube.

The paper was discussed by Messrs. KUNZ, KEMP, and BRAUN.

Dr. MOSES next described a mineral from Arizona which seemed to be equivalent to the rare sulphate Ettringite, hitherto only known in minute crystals at Ettring, Switzerland.

The Arizona mineral resembles pectolite in appearance, but is soft and silky, and occurs in fine, white, radiating fibres upon a silicate of the same bases. The exact composition has not been determined, but approximately it may be given as a basic sulphate of lime and alumina. One analysis recalculated after deduction of gangue showed CaO., 26.32, $Al_2.O_3$, 9.85, SO_3, 18.53, H_2O., 45.30.

The papers are to be published in full in the *American Journal of Science.*

Mr. L. McI. LUQUER, "On the Optical Properties of Cacoxenite from various Localities," and "The Optical Properties of Muscovite from the Kingsbridge Ship Canal."

On Trachosteus and Mylostoma, Notes on their Structural Characters.

BY DR. BASHFORD DEAN.

ABSTRACT.

The discovery of the derm plates of the entire anterior portion of the trunk of *Mylostoma* makes another and important addition to our knowledge of the American Arthrodira.

The material collected from the Cleveland shale at Linton, Ohio, by Rev. William Kepler has recently been added to the Museum of Columbia College. In the present specimens the crushed plates, as displayed upon the slab of clay ironstone, show that the fish was a small one in the group of kindred forms from this horizon. It measures from tip of ethmoid to termination of dorsal shield about fifteen inches.

Mylostoma, hitherto known only from detached dental plates, as described by Newberry in 1883,* and subsequently with figures in 1882,† now proves, as was conjectured, an armored form. Its plates are slighter in character than those of kindred American forms, do not exhibit sculpturing, and in arrangement, as well as size, approach those of the European *Homosteus*. On the other hand it presents evident points of affinity with *Trachosteus*. The present material allows a partial determination of head-plates, dentition, median and lateral dorsals, and of abdominal shield. As usual with Arthrodiran remains, no traces are to be found of visceral arches or of fin structures. It would appear, in summary, that in this form there is a new example and an extreme one of specialization in Arthrodira. In this case the modification has extended to dental plates adapted for grinding, and in all probability to a body depressed dorso-ventrally, with eyes placed dorsally and somewhat closely together, characters which perhaps might be expected in a fish of ray-like habits.

The relations of the Waverly fish fauna, as of salt water origin, to that now known in Belgium, as shown by Lohest, was commented upon, and a brief discussion was given regarding the position of *Coccosteus* among Arthrodira.

The contribution was discussed by Dr. N. L. Britton.

ON AN OCCURRENCE OF GABBRO (NORITE), NEAR VAN ARTSDALEN'S QUARRY, BUCKS COUNTY, PENNSYLVANIA.

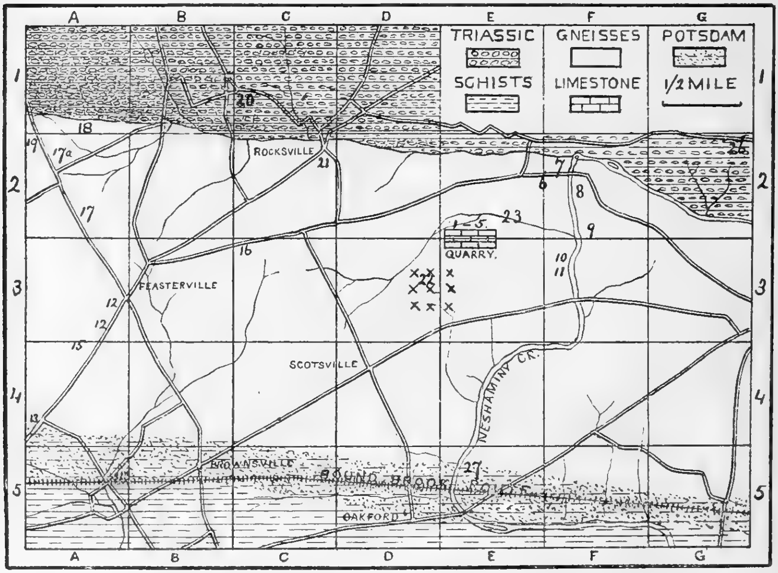
BY J. F. KEMP.

In the winter of 1886 the writer, then abroad, received from Dr. N. L. Britton a series of rocks, that he had collected the previous summer while doing field-work for the New Jersey Survey. Among them was one from the State collections, marked Van Artsdalen's Quarry, Bucks County, Pennsylvania. On microscopic examination it proved to be a norite of singularly fresh condition and of typical mineralogical composition. The interesting, diagnostic mineral hypersthene exhibited its pink and green pleochroism with great vividness, while with it were a light green, monoclinic pyroxene, considerable yellowish-brown hornblende, plagioclase and magnetite. The rock

*Transactions N. Y. Acad. Sci. Vol. II. 147.

†Monograph XVI., U. S. Geol. Survey, 163.

strongly resembled the norites of the Cortland Series,* near Peekskill, and those of the exposures near Baltimore.† Its great freshness gave the impression at the time that it was an abnormal Triassic diabase, and the discovery was held in abeyance until it would be possible to visit the region itself. Meantime Messrs. Campbell and Brown‡ announced the hypersthene-diabase of Virginia and recorded its discovery in western New Jersey and eastern Pennsylvania, by Mr. Darton, so that although it had been learned that Van Artsdalen's quarry is in a little exposure of limestone, in the Archæan strip that crosses southeasten Bucks Country it was inferred that an erratic had



Determinations of numbered specimens of map. 1-5 Limestone and inclusions of silicates. 6. Decomposed gneiss. 7. Dark gneiss. 8. Green schist. 9. Decomposed gneissic gabbro? 10. Quartzose gneiss. 12. Mica schist. 13. Mica schist. 14. Quartzite. 15. Coarse gneiss. 16. Diabase boulder. 17. Coarse gneiss or granite. 18. Gneiss. 20. Conglomerate. 21. Schistose gneiss. 22. Gabbro. 23. Pegmatite. 26. Arkose. 27. Quartzite.

*See J. D. Dana, Amer. Jour. Sci. Sept. 1880, p. 197. G. H. Williams, idem, Feb. 1887, p. 135, Mar. p. 191.

† G. H. Williams, Bulletin 28, U. S. Geol. Survey.

‡ H. D. Campbell and W. G. Brown, Bull. Geol. Soc. of Amer. ii. 339, 1891.

strayed thither. But the past summer, in connection with the summer-school work of our Geological Department, two of our students, Messrs. Ries and Fennor, went, under the writer's direction, to the quarry, and prospected the neighborhood for norite. They were successful, and found the outcrop in the midst of the Archæan crystallines.

The general geological relations are well shown on the larger map by C. E. Hall (Sheet II. of Report C 6, Penn. Geol. Surv.), and on this the accompanying small map has been based. The entire area was, however, covered by Ries and Fennor, and on their collections the rock determinations are based. As is shown on the large map the Archæan rocks just touch the southwest corner of Bucks County, covering a township or two. They are of both massive and gneissic habit, and are collectively summarized by Hall as granitic and syenitic rocks. Ries and Fennor collected some green schist or amphibolite in square F2 of the small map. The general outcrop of this Archæan exposure forms an east and west belt, that at the quarry is about two miles across. The limestone outcrop is found in it at E2 and E3. It has always been a puzzle, because, as stated in Report C6, p. 59, it is the only exposure of limestone that occurs in this Archæan belt. South of the Archæan belt lies the Potsdam quartzite, which, after a short distance, is succeeded by the Manayunk schists. North of the granitic belt there is the Triassic sandstone with a conglomeratic streak along the contact.

Van Artsdalen's quarry is one of the best known and most prolific of the mineral localities near Philadelphia, and it frequently appears in the lists which have been prepared. In Genth's Report on the Mineralogy of Pennsylvania (Report B of the Geol. Survey) the following species are recorded, the number of the page being given after each: molybdenite, p. 10; pyrrhotite, p. 17; pyrite, p. 20; blue quartz, p. 58; wollastonite, p. 64; pyroxene, p. 65; garnet, p. 74; zircon, p. 76; phlogopite, p. 82; muscovite, p. 85; wernerite, p. 86; feldspar, p. 89; orthoclase, p. 94; titanite, p. 103; apatite, p. 109; gypsum, p. 148. In Report BB, p. 225, an analysis of orthoclase is recorded. T. D. Rand, in his Notes on the Feldspars, etc., of Philadelphia and Vicinity (Proc. Phila. Acad. Nat. Sci., 1872), mentions orthoclase, and J. Eyerman in his Mineralogy of Pennsylvania, p. 22, refers to the same material. It has special interest on account of its chatoyant lustre. The notes on the mineral localities near Philadelphia, by Messrs. Rand, Jefferis, and Cardoza, in the Proc. of the Phila. Acad., 1892, p. 182, give another list which mentions in addition to those above quoted from Genth, salite, fassaite, and coccolite.

They also state that the molybdenite is probably graphite. These minerals occur in the bunches of silicates, often of very fanciful shapes, that are distributed through the limestone, much as is the case with so many exposures of the same rock, in the highlands of New York and New Jersey and the foothills of the Adirondacks. Although the breast at Van Artsdalen's quarry is 25′ high, a slab 4′ square could not be obtained free from these inclusions. At times they strongly suggest metamorphosed trap dikes, and certainly in their mineralogical composition recall the results of contact metamorphism. In the thin sections prepared from them I have been able to recognize hornblende, light green pyroxene, titanite, rutile, orthoclase with microperthitic albite, zircon, apatite, pyrite, scapolite, and plagioclase. Of the exposures which show near the quarry, No. 23 (the numbers refer to the field specimens), in E2, is a very coarse, and probably pegmatitic granite ; No. 22, on the line between D3 and E3 is *norite ;* No. 6 in F2 is a decomposed gneiss ; No. 7 is a dark gneiss ; No. 8 is an amphibolite ; No. 9 contains quartz, pyroxene, and orthoclase, and has suffered dynamic strains ; Nos. 10 and 11 appear to be quartzose gneiss and have the peculiar blue quartz in them that is characteristic of this belt ; No. 12, from the nearest exposure to the west, is a decomposed mica schist. No. 7 above contains crushed quartz and feldspar, and nests of little green hornblende and biotite rods that are the results of dynamic metamorphism after some original bisilicate, a few decomposed cores of which remain. It seems to have been a pyroxene. The rock has suffered severe strains and crushing. The determinations of the other numbers are noted in the description of the map. Outcrops in the region are none too numerous on account of the dense, vegetable growth, and the high state of cultivation. The norite is the most interesting of all. It might ordinarily pass for a dark gneiss. The slides show with the hypersthene, green monoclinic pyroxene, hornblende, plagioclase, garnet, magnetite and apatite. The hypersthene has the usual pink to green pleochroism and parallel extinction. The monoclinic pyroxene is light green, and is the same as the one which is very common in the so-called norites of the Adirondacks. Garnet is in such relations to the bisilicates as to suggest some secondary metamorphism. The hornblende is brown, and is far inferior to the other bisilicates in amount. These minerals are very much the same as those that have been described in the norites and gabbros, that occur near Peekskill* in the igneous rocks of the Cortland

* G. H. Williams, Amer. Jour. Sci. Feb, 1887, p. 135.

series, and in the other related rocks from the well-known exposures near Baltimore* and in northern Delaware.†

C. E. Hall records also black boulders from the roadside toward Feasterville, and a number of other rocks from the neighborhood, whose microscopic description attracted my attention. Fortunately in the careful methods practiced by the Pennsylvania Survey, as regards their museum material, they were all recorded by numbers, and by the courtesy of Professor J. P. Lesley I have received some chips for thin sections. The "diorite?" No. 5306, is an olivine-diabase, and undoubtedly a stray Triassic boulder. Ries and Fennor found one of much the same character (No. 16). It was only provisionally called by Hall "diorite?" His analysis is quoted below. No. 5309, called provisionally "syenitic gneiss?" contains shattered quartzes, orthoclase and decomposed garnet. The dark silicate is too much altered for recognition, but it probably was hornblende. Nos. 5305 ("trap") and 5307 ("black syenitic gneiss") are both formed of green hornblende in largest amount, with much less plagioclase. They are amphibolites rather than trap or diorite, and are doubtless much metamorphosed igneous rock of an original dioritic nature. They are very like our No. 8, which was gathered east of the quarry. The association of such rocks, with norites and gabbros, is known both at Baltimore and in Delaware. The analyses of two of the above numbered specimens yielded the following (5306 is by C. E. Hall, 5309 by F. A. Genth, Jr.):

	5306.	5309.
Loss.	1.50	1.43
SiO_2	47.79	73.26
TiO_2	1.00	0.49
P_2O_5	0.17	0.25
CO_2	0.57	——
Al_2O_3	16.58	12.41
Fe_2O_3	2.93	1.53
FeO	9.05	2.34
MnO	——	tr.
MgO	8.17	1.06
CaO	9.33	1.23
Na_2O	2.20	2.68
K_2O	0.40	4.51
	99.69	101.19
Sp. Gr.		2.689

* G. H. Williams, Bulletin 28, U. S. Geol. Survey.

† F. D. Chester, Bulletin 59, U. S. Geol. Survey.

This occurrence of norite, although clearly restricted in area, is interesting for several reasons. It indicates in the first place, an outcrop of this rock in the extended interval between Peekskill on the north and Baltimore on the south, which was not hitherto known to contain it. In Volume I of his Final Reports, pp. 107–108, Professor Lesley remarks, with some surprise, on the absence of the "Labradorite" rocks or Norian in this Archæan belt. The rocks here mentioned are entirely analogous to many in the Adirondacks. But I would not wish to imply anything of their geological age from their mineralogical composition. They may be merely an intruded knob or large dike. We have also in the Columbia College collections a slide of a rock, which was collected by Dr. Britton from a cut on the Ogden Mine Railroad north of Minnesink, N. J. It is a well marked gabbro with a little hypersthene. The slide shows plagioclase, green monoclinic pyroxene, greenish hornblende, magnetite, apatite, and the little hypersthene referred to. Probably other occurrences will be found in the great exposures of the crystalline rocks of the Highlands. R. W. Raymond has called attention to titaniferous ores in New Jersey at the town of Bethlehem. (See discussion of paper by H. B. C. Nitze on "Magnetic Iron Ores of Ashe County, North Carolina," at the Baltimore meeting of the Institute of Mining Engineers, February, 1872.) It would be quite natural from what we know of these ores in the Adirondacks and in Sweden to find them associated with rocks of the gabbro family.

The second interesting point is that the minerals in the limestone at the quarry are probably the result of contact metamorphism wrought by the plutonic rock mass on the neighboring limestone. While much the same series occurs in the regionally metamorphosed linestones of Canada and elsewhere, where no igneous rocks have been mentioned, the list does present some striking similarities with those which have been formed by contact action or limestones in many parts of the world. Although few cases are recorded where these effects are due to rocks of the gabbro family, we have descriptions of many such contacts of diorites, syenites and diabase in the Tyrolese Alps, with which the Austrian geologists—Tschermak, Reyer, Lepsius, and others—have made us familiar. Many of the minerals mentioned above appear there, but in Pennsylvania we lack vesuvianite, which is often characteristic of such surroundings. G. H. Williams found at Stony Point on the Hudson, a narrow strip of limestone between mica-diorite and peridotite. It contained malacolite, light green hornblende, zoisite, sphene and scapolite. We have all of these except zoisite. If the limestone of the quarry could be traced to its contacts with the surrounding rocks, an undertaking that is prevented by the lack of outcrops, it is quite probable that it would prove to be an included piece caught up in an igneous mass, and that thus its isolated character would find a reasonable explanation. Professor Lesley surmises that the great developments of limestone in New Jersey may lie far below the surface in Pennsylvania (Final Report, Vol. i, p. 111.) If this be true the limestone may have become involved in the igneous rock during the passage of the latter upward.

Mr. G. K. Gilbert, of the U. S. Geological Survey, exhibited photographs of a gaping fissure in the Aubrey limestone, twenty-five miles north of Cañon Diablo Station, Atlantic and Pacific Railroad, Arizona, and referred it to anticlinal rolls, as there was no faulting.

Prof. Kemp remarked on its interesting relations to many mineral veins.

Dr. Bolton read a letter from a representative of the Smithsonian Institute asking for information and analyses of mineral spring waters.

January 30, 1893.

Stated Meeting.

Vice-President Dr. Bolton in the chair, about fifty persons present.

The minutes of December 19th were read and approved.

The following paper was then read, illustrated by experiments:

FACT AND FALLACY IN THE BOOMERANG PROBLEM.

BY C. H. EMERSON, WHITEHALL, N. Y.

I advance the statement, that—

The Australian boomerang does not possess a single desirable quality for an ideal boomerang flight, excepting only the general consideration that it is made of wood, and has its centre of gravity to one side of its main outline of figure.

I refer only to the returning boomerang, the principal features of which, as stated by various authorities, are: In general, the parabolic or hyperbolic curve; in particular, the rounded upper side (in cross section round on one side and flat on the other) and always thickest in the middle; a screw shape warp or twist, and a wavy or dented upper surface.

When I reflect that it is only such a statement of fact, well substantiated, that merits the interested attention of this society, I feel that an apology is due at the outset for the entire absence of corroborating formulæ and equations, from what I have to present, especially as the somewhat astonishing literature of the boomerang bristles with the pointed persistence of the one idea, that this dynamic mystery is a case for mathematical formulæ, if there ever was one.

In other words, it seems to be the conclusion by general consent of most writers on the subject, that until the mathematician allays the uneasy spirit of this "scientific vagabond," by the weight of his rigid equations, it will remain to most people the fascinating and unsolved riddle that it is.

Therein I find my excuse for asking your attention to a brief review of the literature of the boomerang, before turning my slender little brood of naked facts over to cold, scientific criticism.

The latest publication of any moment that has come to my notice is that in *Scribner's Magazine* for March, 1890, by Mr. Horace Baker, who had made a practical study of the boomerang, and had learned directly from the natives how to make and throw it successfully, an accomplishment of which the encyclopædias say, "Europeans find it next to impossible to acquire."

Mr. Baker calls it, "that dynamic curiosity which still remains a puzzle to the civilized world," but adds, "I believe it is possible to make a boomerang by exact mathematical calculation, but yet I have never seen two exactly alike—of two apparently alike in every particular, one rose buoyantly, while the other fell dead." Thus the majority of writers upon this subject, seem to acquiesce in a sort of Pythagorean belief in the mystical power of the science of numbers, to explain the puzzling phenomenon of the boomerang's flight, though there are notable exceptions. For instance: In 1837, Prof. McCullagh, of Edinburgh, read a paper on the subject before the Royal Irish Academy, in which he pointedly said: "To calculate the mutual action of the air and of a body to which is communicated at the same time a rotary and a progressive motion is a problem which far transcends the present powers of mechanics." In the face of this early warning, the literature of the boomerang is a long record of attempts to solve it by calculation. It seems to warrant the expectation that of all valiant heroes, the mathematician will ever be the first to tackle the chip on the shoulder of incredulity. In this case the incentive was a strong one, and the chip was unbearably exposed in such taunts as that in Latham's English Dictionary, viz.: "The boomerang is a puzzle and even mathematicians cannot comprehend the laws of its actions."

How the civilized world was aglow with the query, "What makes it come back?" and how strong the incentive was to satisfy the popular demand for a solution, is most graphically pictured in the following extract from an editorial in the *Dublin University Magazine* in 1838. The editor says:

"Of all the advantages we have derived from our Australian settlements, none seem to have given more universal satisfaction than the introduction of some crooked pieces of wood, called boomerang. Walking sticks and umbrellas have gone out of fashion; and even in this rainy season no man carries anything but a boomerang; nor does this species of madness seem to be abating. It would be utterly impossible for any periodical professing to give an account of the subjects which from time to time occupy the public mind, to leave out of its record all notice of the strange passion which has converted all classes of our fellow citizens—dignitaries of the church, fellows of our colleges, grave divines and sober merchants—into boomerang throwers."

The editor then discusses at length the principles involved and attributes the phenomenon of its strange flight to its rounded upper side.

Another writer in the *London and Edinburgh Philosophical Magazine* of 1838, also finds the solution in the rounded upper side. He cites the curious law of fluid resistances laid down by Newton (see Principia, Prop. 34, Lib. 2), and concludes that the flat side of the boomerang, the down side in throwing, will suffer, if not twice as great, at least much greater resistance than the rounded upper side, and so the missile would rise.

I shall not dispute that reasoning, but what shall we say to these philosophers if it shall turn out that our ideal boomerang, with both sides flat, and no round side at all, will mount the air like a bird, and soar and return?

Unheeding the calm caution of McCullagh, the bold mathematical Don Quixote with poised pencil rashly charges upon a wind-mill and is thrown. But these philosophic assertions are more insidious foes to public confidence in our stock of knowledge. Look at the encyclopædia for instance which says of the boomerang: "It is thrown bulged side down. * * * Its surprising motion is produced by the bulged side of the missile. The air impinging thereon lifts the instrument in the air exactly as by hitting the oblique bars of a wind-mill, it forces it to go round. The ingenuity of this ancient weapon, which is worthy of the highest scientific calculation, is very extraordinary as coming from the almost lowest race of mankind."

Extraordinary is too mild a term. When a black savage from "almost the lowest race of mankind" can, by the deliberate exercise of his inventive ingenuity, succeed, if not in turning our very philosophy upside down, at least in so effectually confounding a popular educator of the highest race of mankind, that he subverts the very laws of fluid resistances, requiring that the boomerang should be thrown bulged side down in order that the "air impinging thereon" might lift it, etc., when, as a matter of fact the boomering is never thrown bulged side down, and even if it should be, the effect would be exactly the opposite from that stated.

Any one who has ever been pulled nearly off his feet by the wind getting on the wrong side of his umbrella, knows the truth of that statement without once thinking of the immortal Newton, or his prop. 34.

I take this opportunity to say: I do not believe there was a particle of ingenuity exercised in the creation of the first returning boomerang. I believe, as suggested by Pitt Rivers, F.R.S., in the *Anthropological Journal,* that it may be very easily explained. But, not to commit the very error I am condemning in the encyclopædist, and set up imaginary causes as dogmatic assumption of fact, I will, in attempting to tell the story of its origin, admit that it is a flight of fancy—and so I begin with the good old and appropriate phrase:

Once upon a time many years ago there lived in the bush of Australia, a wild and woolly black man. One particularly hungry day, while roaming his native haunts in search of food, he came suddenly upon a wild animal, large, powerful and fleet of foot. He grabbed the nearest missile at hand, and hurling it with all his eager might, broke the leg of a bouncing kangaroo.

With this advantage gained, the fierce and hungry savage soon throttled the disabled game and appeased his appetite. But he failed not to note that the successful weapon which chance had thrown in his way, was a heavy, crooked stick. He noted well its elbow-like bend, its whirling motion and wide range, and he straightway proceeded to cultivate his lucky throwing club.

Indeed, so easy and natural a step was this in the inception of the art of maiming game, that the braves of all lands seem to have known the wonderful virtues of a curved club, and some gods as well, if we may believe what Mr. Ferguson and philology reveal, viz.: that the "Cateia" of the Romans, and the "Ancycle" of the Greeks, was the same; and that "Cateia" and the curved club of Hercules was one and the same thing. And then there are the pictures of curved weapons in the hands of ancient Egyptians, while actual specimens exist in the Boulah Museum at Cairo, and in the British Museum from Thebes, in the Louvre in Paris, and in the Ethnographical Museum at Copenhagen. And here, right at home, we have specimens of the bent rabbit clubs of the Zunis and the Moquis, in the Smithsonian Institution at Washington.

And further, Mr. Ferguson asserts that the *curved throwing club preceded the spear*, and notwithstanding the claim that has been made that the Australian boomerang was derived from some hypothetical high culture, I maintain there is excellent grounds for my fancy that our wild Australian friend's first kangaroo dinner was won with a crooked stick.

But even this round bent club, though whirling in a wide range when thrown, was not *always sure* to hit the mark intended; and as some of the greatest achievements of the white man's genius have been opened to him by accident, so one time the lucky club of our black friend missed its mark, and striking with great force against the sharp edge of a stone, was split along the grain lengthwise into two parts.

The black fellow, with rueful countenance, picked up one of the rent parts, only one half of his trusty, lucky club, smoothed and carved with laborious care from dense and heavy wood—now ruined—lightened by half and useless. With disappointment and vexation he flung it far from him. How it sped away! It swiftly mounted on the air like a bird, and poised and wheeled in circling flight. When, lo! the returning boomerang had sprung into existence! The luck of his old club had turned to magic. It was as if he had seen, while gazing into a swift running stream, the gliding of its waters suddenly cease, and before his very eyes turn and flow merely back again, instead of going "on forever."

So much for fancy. Now for fact. It is a very significant fact, that in their round, or unsplit state, the curved throwing club does not possess to any noticeable degree, the quality of returning flight.

Here are two small model boomerangs, rounded on both sides. A light throw, thus, and it goes onward, but shows no disposition to return.

In this shape they are used as weapons of war or in the chase.

But when this rounded model (made from two pieces of a cigar box, glued together flatwise, but with a sheet of paper between them) is split apart, thus, we have two boomerangs, each flat on one side and round on the other, and in this simple change of configuration they possess the quality of returning flight to a surprising degree. In this shape they are fit for use only in sport.

In the course of time discoverers reached Australia, and it is not to be wondered at that the earlier descriptions do not discriminate between these two distinct shapes and uses of the boomerang. In an old engraving published by J. Stockdale, London, 1798, it is named a "wooden sword." Also a drawing by Lesseur in Peron's Atlas calls it "Sabre a' ricochet"; while Dawson calls it the "boomerang or stick with which they throw their spears." Another early explorer, Mr. Ogle, enlightens us by stating that "in every part of this great continent of Australia they have the koilee or boomerang (which the ancient Egyptians possessed). . . . It is used by them in skinning animals they have killed."

Did the cunning savage purposely mislead enquirers? At all events it turns out that there is a wonderful diversity of opinion as to what are its really requisite points of construction, as well as to what is uses were. For instance, we read from the "Natural History of Man." by J. G. Wood, M.A., F.L.S., etc., that "the various points which constitute the excellence of the missile are so slight, that there is scarcely an European that can see them . . . ." And he speaks at length of the wonderful care and whole days of patience required to make a good one, and of the powerful effect produced by a single chip in the making.

It is surprising to note how mere irregularities, inseparable from the crude work of the savage, have, under the miscroscopic gaze of investigators, been magnified into all-important essentials.

For instance, no less an authority than Lieut.-Col. Sir Thomas Livingstone Mitchell, Surveyor-General of Australia, who studied the boomerang minutely, was the *first* to discover (1846) in the uneven splitting of the bent limb, of which it was usually made, its hitherto deeply hidden secret, as he thought at least, viz.: That this uneven splitting was in reality a *carefully wrought screw-shape warp or twist*, whence its wonderful powers.

Sir Thomas (like some of the rest of us) had an eye to benefiting mankind, and he applied what he called the "Boomerang Principle" to a new form of propeller for steam vessels, and actually patented the same in England and America in 1848.

You may find in the dusty tomes of the Patent Office his interesting specifications, wherein he puts it on record that "The 'Bommareng' (as he spelled it), is a remarkable species of missile in use amongst the savages of Australia, and is a bent blade, so warped as to form a portion of a screw."

Brande & Cox, in the "Dictionary of Science and Art," speak rather vaguely of this invention as "the plane of a screw equally poised obliquely about a balanced centre." But as one writer naïvely says, "The idea never found favor with ship builders." But Sir Thomas had, among theorists, at least, a warm and enthusiastic following—perspiring, I might add, for one professor narrates how he stood over a pot of boiling water for two hours in order to give to a boomerang he was making its *requisite warp.* Prof. Erdmann, of Berlin, in Poggendorff's Annalen (1868) records how he found this essential warp or twist to amount to exactly 17 centimeters—about 20 degrees.

Prof. Werner Stille says also in Poggendorff's Annalen (1872), "The essential parts in fact are the warped surface; when the instrument rotates in the air this surface acts similar to a screw or to the sweep of a wind-mill." But he adds, "The problem can only be considered as solved when we possess the equations of the curves described by the instrument—the solution has not hitherto been successfully made." And he proceeds to make it and wields the process of the calculus through some sixteen pages of convincing (?) calculations, based upon the warped surface.

Lieut.-Gen. Pitt Rivers, F.R.S., in the *Anthropological Journal,* says, "The form of the returning boomerang, its curve, its twist, and its peculiar section, have long been known. It has a slight lateral twist, by means of which it is caused to rise in the air."

We read also in Smyth's "Aborigines of Victoria": "I never saw a wonguim (the boomerang that returns), made by the natives of Victoria, that was not twisted."

And again, Carl Lumholtz, M.A., member of the Royal Society of Science, of Norway, in his book, (Among Cannibals" (1889), says: "The peculiarity of the boomerang, that it returns of itself to the thrower, depends on the fact that it is twisted; the twisting is accomplished by putting it in water and then heating it in the ashes, and in finally bending it; but this warp must be occasionally renewed."

Thus by eminent authorities the screw twist assumes a position of even greater importance among the so-called essential qualities of a good boomerang than that of the rounded upper surface. We express no wonder at the mistakes of early explorers, but what shall we say to these more recent and most eminent authorities, if it shall turn out that our ideal boomerang not only has both sides flat, and no round side at all, but that each flat side is wholly within one plane, and each parallel to the other? We thus exclude all possibility of a screw-shape warp or twist.

The fact is, the boomerang takes its paradoxical path, not because but in spite of a screw-shape twist, the existance of which may be easily accounted for. Every farmer's boy knows that a round limb will split in half; *i. e.*, through the heart easier than any other way; and that the split will follow the grain. Now the great difficulty would be not to get a stick that would split twisting, but one that would not. Indeed, nature is so gracefully easy in her ways that it would be next to impossible to find the limb of a tree so precise in growth that its split side would be all in one plane. Every skilled mechanic knows that it takes tools and machines of the utmost precision, results of the highest skill in the art, to bring any material surface into a perfect plane. How then could the Australian savage, from almost the lowest race of mankind, avoid a warp in his split boomerang?

You have a warped board. Wet it upon the concave side and apply heat to the convex side and you straighten it. Could it be that the wetting and heating which Prof. Lumholtz observes was not to warp, but to lessen or correct a natural defect in the split boomerang?

Prof. Joseph Lovering, of Harvard University, read a paper before the American Academy of Arts and Science in 1859. He makes some very acute observations concerning the inclination of the throw and its consequences. His calculations were based upon an element of "back pressure," resulting from the "throw," to solve the problem.

One final instance of the black man's remarkable ingenuity finding an answer to the black man's puzzle, occurs in a recent number of *Scribner's Magazine*, and is as follows:

"The secret of its peculiar flight is to be found, not so much in its general form, as in its surface. This, on examination, is found to be slightly waving and broken up by various angles. These angles balance and counter-balance each other; some by causing differences in the pressure of air on certain parts give steadiness of flight and firmness; others give buoyancy, and *each* has generally to be determined practically by experimental throwing—when these dents or angles are properly arranged, the boomerang goes through the air somewhat as a screw propeller goes through the water," etc.

It is no longer that the boomerang must have equations for a peculiar curve ; it is not that its points of excellence are so slight that Europeans can scarcely see them ; it is not that its top rounded side brings it under Newton's proposition 34 ; it is not that it must have a screw-shape twist ; it is not that an element of back pressure unveils the mystery ; but the secret of its magic power is now found to reside in a great multitude of little "dents" chipped from its surface.

And so the magnifying of inherent faults or imperfections into qualities of the greatest importance, culminates in this curious way, while in fact, as I believe, these "dents" are but the evidences of rude and primitive knife cuts—possibly scooped out by a sea shell or an opossum's tooth, for want of better tools, and are of æsthetic or duthropological rather than of mathematical interest ; with no further import than the much prized hammer marks in antique brass.

It is these varying and contradictory theories that constitute for the most part what I have already termed the somewhat astonishing literature of the boomerang. I have reviewed them because it is necessary to rid our minds of their influence. Not that I have the presumption to intimate, even remotely, that a good physicist needs to have this pointed out to him by me, but principally because good physicists have evidently never attemped a solution of the difficulties, and so have, possibly, by their mere inattention, permitted thoroughly competent mathematical skill and effort to be wasted upon a misapprehended basis of fact, reported by presumbly competent authority.

Few people, comparatively, have ever seen a boomerang, and fewer still have ever studied it, or seen it thrown. What, then, could be more misleading than to liken the motions of a boomerang to the sweep of the oblique of a wind-mill? or worse still, to say that it goes through the air somewhat as a screw propeller goes through the water?

The screw of a propeller rotates edgewise, but the progress of the screw is bodily, along with the ship, "broad set to the door," so to speak. The two motions are in different planes, at right angles with each other, whereas both motions of the boomerang are edgewise, in the same general plane and direction, and cannot be compared to the progress of a screw propeller in water, except to utterly mislead the mind.

Comparatively few writers on the subject have taken the pains to go beyond the matter of shape, and look into the element of artificially applied force and motion, for the true solution of its action.

A paper published in the "Journal of the Royal United

Service Institution" in 1869, by A. H. Lane Fox, who, by the way, is the same personality as Pitt Rivers, F. R. S , already quoted, correctly states one of the principles of action in the boomerang as parallelism of axis. This was, however, first published I believe by an American, Prof. Snell of Amherst, in 1855, in a lecture on "Planetary Disturbances," in which he said:

"We find an elegant illustration of this tendency to parallelism of axis in the boomerang."

But "Parallelism of Axis" is a condition of free motion, and so we are brought to consider the elements of artificially applied force and motion as something of the very first importance. And here we confront another surprising fact in the literature of the boomerang, viz., no mechanical means of any kind, so far as I can find, has hitherto been devised to make repeated projections under similar conditions as crucial tests.

Evidently, then, the first step to be taken was to supply this deficiency. The usual lecture-room expedient of striking a cardboard boomerang from the side of a book, is against good mechanical principles for obtaining extended flights. The mechanism should stimulate the action of the human arm—the most perfect catapult ever devised—but unlike the arm its motive power must be subject to being held indefinitely to the same line on a graduated scale. Such, in a general way, I decided in my mind, should be the characteristics of a machine to make tests.

The next step was to adapt the details of construction to the theoretically best form of missile. But that form had first to be determined. Theory alone, unaided by additional experiment, finds reasons (as will be apparent) to decide against the necessity of either a screw-shape warp or twist or convex upper surface. So, to make a first experiment, I went to a planing mill and selected a thin, hard maple board, and had it planed down to an even thickness. The thought struck me that possibly the cycloidal curve for advancing outline would cause the minimum of air resistance. I constructed a slightly prolate cycloid, with a centroid of $4\frac{1}{4}$ inches, giving me an outline of about 16 inches. Instead of ending the curve abruptly at the base line, I added a spur to each end below the line, shaped somewhat like the prow of a boat. This received no secret touch in making. A prosaic jig-saw shaped it and left its edges square and rough. I sharpened the pioneer edges slightly to better cleave the air, taking care not to disturb the cycloidal outline of the under or bearing surface. As a precaution against being warped or twisted by exposure I soaked it in oil and turpentine, and varnished it.

Here, then, is a theoretical boomerang. Will it go? Permit me to add here what may strike you as a curious oversight. Up to this time I had never seen a boomerang to notice it. In the light of all I had read about the extreme difficulty of making a good one, I took good care that no one was around to observe my first attempt at hand throwing. The narrative may interest you. I found an open space behind a pile of lumber. I looked all about. I was alone. I determined to make a light throw at first, and the first thing that astonished me was the comparatively enormous distance that it travelled upon a slight impulse. Its weight was less than two ounces, and yet it went over 200 feet away. It rose swiftly in the air, whirling and flashing in the sunlight, and, as I thought, extremely beautiful in the graceful ease of its motions. And could I believe my eyes! Yes! it was coming back. It fell within a yard or two of my feet. I picked it up, fully as delighted as ever that black savage could have been who stumbled upon its first discovery, and became a blessing to his race.

I have so far carefully noted inaccuracies in defining the characteristic motions of the boomerang. Permit me to add still further of the distinct peculiarity of the boomerang:

That in its motion of translation, its axis of figure turns longitudinally with it—a requirement as incompatible with the proper action of a wind-mill or a screw propeller as tipping a wheelbarrow bodily, end over end, would be difficult compared with its proper use.

Its real motions, then, correctly apprehended, practically constitute the instrument an æroplane, pure and simple, in which no screw-shape warp or convex surface is required.

It is a projectile with an excessive sensitiveness to atmospheric influences, to be controlled in flight by the qualitative and quantitative character of the mechanical projection to be imparted to it. What shall be the ratio of the speed of gyration to that of transition? Is there a limit to attain? For I am seeking to obtain an ideal flight by mechanical means. That is to say, one which shall be straight away, shall rise and soar and return, without veering far from a vertical plane.

It is well known that the flight of the Australian boomerang is invariably in a more or less circular orbit. Its motions when thrown by the hand are comparatively slow. I therefore furnished my machine with the means of increasing the speed at will, and of adjusting the relative speed of one motion to the other.

In this connection it may be interesting to note the remarkable discovery of Scott Russell, viz :

That the speed of the propagation of the free, solitary wave in water, was the definite speed at which a horse could draw a canal boat more easily than at any other speed whatever, be it less or greater, because it agitated the water less.

With these considerations noted, I pass to a brief reference to the results of actual experiments.

I found that the possible variation of the flat figure in a boomerang within certain limits, was practically inexhaustible. The limit at which boomerang action was the least noticeable was the flat circular disc.

In a general way it was most apparent in the shape in which much the greater part of its outline of figure oscillated from one side to the other of its centre of gyration, while even a flat, rectilinear figure developed a well-marked effort to return. My best results were with the cycloidal missile, which had an area of from 12 to 15 square inches to the ounce in weight, used with a throwing arm whose radius was 14 inches, in which the biceps muscle was represented by a spring tension of about 25 pounds. Under these conditions the straight return was repeatedly accomplished. But if the spring tension was carried to a point largely in excess of the amount noted for the same boomerang, the outward flight was one of great swiftness and precision; but the subsequent result was truly astonishing. After reaching its outward limit, and after starting well back upon its return, it swept suddenly round again in the direction of its rotation, and started forward upon a second onward flight, like our late comet, waltzing from one vortex to another. Finally it returned in a wide circle to the left.

Before passing to a conclusion, possibly some further explanatory considerations of the foregoing facts and experiments may not be without interest.

First, as to original defects:

Quintillian has said: "Everything which art has brought to perfection had its origin in nature." And while in the case of the boomerang its origin may have been in nature, I believe it was not one of intent, but of accident. And the reason why the obscure defects, with which accident endowed it at its birth grew to be actually regarded as essential qualities, I believe was simply because neither art nor science had devised any mechanical or crucial tests to take the place of the variable and unreliable hand throwing. The effect of a slight change in the impulse is greatly exaggerated in the flight; and as no man can be quite sure of throwing a missile twice alike by his arm alone, the effect of inherent faults could not easily escape detection.

Second, as to experiments with various forms:

In the case of the circular disc referred to, its tendency was to develop a spiral trajectory, in which first one side and then the other was uppermost, as if there was no such thing as "parallelism of axis" to disturb its sinuous inclination. But it is almost impossible to produce some of the finer details of action in the restricted experiments of a limited space, and this is one of them.

You may have to watch sharp to detect this peculiar tendency of the circular disc. When I throw it from *this* position, its rotation will be from right to left, and it will be its left side that will gradually rise in its effort to develop a spiral trajectory —thus :

If I reverse my position the other edge will rise thus :

A lucky throw, you observed ; it turned completely over before striking the wall.

Possibly this is partly due to the fact that it is more difficult to give this figure a high rate of free gyratory speed, but mostly to the fact that the motion of gyration on one side is in the direction of its progress, and thus directly opposed by the atmospheric resistance to progress, while at the same moment of time the other side turning in an opposite direction receives less resistance to its circular motion, and the side meeting the least resistance is forced upward *by the wind of advance*, until it passes the vertical, and the opposite side succeeding to that position finds its own motion less opposed, and rises in its turn, and so the spiral motion is made continuous.

Obviously this effect is present in the least degree in the boomerang missile which at a given instant of time has the larger part of its exterior outline figure upon one side of its centre of gyration.

It is present also in any figure in which the parts may be on the other hand symmetrically disposed about the centre of gyration, but such that the wind of advance does not meet an unbroken surface, but has an opportunity to slip over some part of the upper surface, as you may observe when I throw these forms (which, of course, only show to a much less degree the power to return).

In the true boomerang the oscillating of its frictional outline of figure about the centre of gyration, breaks or intermits the continuous effect of the wind of advance, which produces in the circular disc the tendency to a spiral trajectory. It explains the cause of that remarkable effect which adds so greatly to the charming beauty of the boomerang flight, and which has been the cause of considerable speculation hitherto in the minds of investigators, referred to by various writers as the "nutation of its axis." You observe this form returns directly to my feet.

Referring again to the matter of definite speed, illustrated by Scott Russell's discovery for the medium of water, I quote from Prof. S. P. Langley, of the Smithsonian Institution, who makes the entirely new proposition in a recent publication, entitled "Experiments in Aerodynamics," viz.:

That for a body moving in air "the more rapid the motion is, the less will be the power required to support and advance it up to some remote limit not yet attained by experiment." In this connection I venture the belief that this limit of speed has been attained for the boomerang in my experiments.

I have not the time to quote various authorities concerning one particularly remarkable phenomenom of the boomerang flight. So far as I can find, no explanation has been offered for it. I refer to what is usually called its *reverse curve.* For instance, all observers agree that the invariable result of a right handed throw is a more or less circular orbit—to the left, in the direction of its rotation. But at the end of its return course it makes a reverse curve—opposite to the direction of its rotation—the return flight tracing an imaginary letter S. I have never found a hint of its solution in the plentiful theories existing, and its cause seemed a most tantalizing and hopeless mystery, until the requirement of a definite speed dawned upon me. Then it was clear.

The acceleration of its return speed, under the law of falling bodies, is sufficient to reach the definite speed required to make the boomerang soar. That is, its advancing edge is again lifted by the wind of advance as it nears the earth. Its right-handed throw gives it an inclination which it will retain throughout its course, and so it again veers to the left. But as its course is now reversed from the direction of its outward flight, of course its curve is reversed.

One object of my experimentation was to attain an ideal boomerang flight ; that is to say, one in which the two motions could be so nicely adjusted, that its return flight should terminate just at the moment it second soaring speed should be attained, thus avoiding the reverse curve, adapting it in short target practice, wherein the target is behind the shooter.

Another object was in a different direction, and in its pursuit I have developed certain refinements of configuration, which are most beautifully adapted to illustrate certain other principles involved, exceedingly interesting in their nature, but as my time is about up, and as their application to a possible useful purpose has not yet reached a stage to warrant their disclosure, I will leave the further consideration of the subject to some future occasion. I will add, however, that Prof. Langley (already quoted) has in the same publication tabulated the speed at which planes of varing angles of inclination must be driven against the air to rise and "soar," as he expresses it. But in his experiments a rigid arm stretched out to keep his Aeroplane constant in its field of action, and if we imagine that this support is instantly severed, just as the proper speed to cause the plane to "soar" is attained, the result is disastrous to a continuous flight. Unless the plane is whirling, atmospheric resistance immediately upsets it, and it falls in fantastic curves, lifeless and inert, like a kite with a suddenly severed string. I have stated that my boomerang is a whirling aeroplane, pure and simple. And now that we have ascertained a definite speed to cause it to soar, it is obvious that it cannot do otherwise than return in a backward flight, after it progressive force is spent.

It happened that in explaining the principles involved to an enquiring friend, I used the term a "Gyrostatic domination." He seemed to be quite satisfied for the time, but after a moment's thoughtfulness he said: "Doubtless you are right—but I'll be hanged if I can see what makes it come back."

I offered once a little prize for the best answer as to what makes it come back, and I was favored with a large amount of of correspondence from all sorts of people, but the most of them rehearsed that abominable description in the cyclopedias, about the oblique bars of the wind-mill, but the most remarkable one of all, in fact the one which truly solved the problem in the fewest words was from a mere child, and it was original. It was a follows:

"Dear Mr. Emerson:

"I am a little boy nine years old. *God* makes the boomerang come back."

So to soar a little in amplification of this dear little fellow's answer, it may be said that the same invisible arm which stretches out with subtle power to hold the ponderous worlds in their awful flight, gently upbears in open palm this simple piece of whirling wood till its orbit is complete.

But to descend to more definite and solid English, I prefer the term "gyrostatic domination" to "parallelism of axis" in expressing this sustaining force. "Fixity of the plane of rotation" may be equally expressive. If, then, we give to our whirling Aeroplane the definite speed required to cause it to soar, its fixity in the plane of rotation will hold it constant to its original inclination, while the wind of advance will lift its forward edge, and at its utmost reach of progressive force, still whirling swiftly, it "touches the button," if you will pardon the expression, for its return, and gravity "does the rest," sliding it down to Mother Earth along the line of least resistance, which is the direction of its inclination, caused by the wind of advance.

It is a somewhat singular fact that after several years of experiments with a great variety of shapes, the one which I have selected as best suited to popular use, is the same figure with which my first experiment was made, built upon the theory of its requirements. And I must add, that as against the unqualified assertions of very eminent authorities, viz.: That it is "impossible to aim accurately with the returning boomerang," quite an astonishing degree of accuracy may be attained by the methods which I pursued. And it is this shape which makes possible the statement at the beginning of this paper, for it has not one of the enumerated essential features of the Australian Boomerang. Its curve is not parabolic; it has no convex upper side; it is not thickest in the middle; it has no warp or twist, and it is not dented.

While I leave something interesting untold, I will, however, add in a general way in conclusion, that I believe my application of the principles involved will solve the problem of "stability" for the "Ariators," which they have so long sought in vain, and for the want of which their models of flying machines, though they would rise without the aid of a bouyancy chamber of any sort, were quite as likely to proceed end over end or wrong side up, as the right way. My belief is based upon the fact that a small flying model of my own make, not only proceeded right side up, but it alighted gently upon its feet, so to speak, every time.

And so it may be said that this "scientific vagabond," as the boomerang has been called, has been carrying around with it a secret, which, let us hope, may some day serve a useful purpose for the good of mankind.

February 6, 1893.

REGULAR BUSINESS MEETING.

Vice-President DR. BOLTON in the chair.

About fifteen persons present.

The minutes of January 9th were read and approved.

The following persons were elected Resident Members:

PROF. WILLIAM HALLOCK,
MR. DELANCEY W. WARD.

MR. OSSIAN GUTHRIE, of Chicago, was elected a Corresponding Member.

PROF. D. S. MARTIN announced the death of F. A. GENTH, a Corresponding Member, and remarked on his important contributions to mineralogy and chemistry.

ASTRONOMICAL SECTION.

The Section was called to order at 8:15 P. M., PROF. REES in the chair.

The minutes of the previous meeting were read and approved.

The Secretary called attention to a subscription in aid of the memorial to GAUSS and WEBER, which is to be erected at Göttingen, and offered to receive and forward contributions.

MR. JACOBY announced that the Rutherford photographic measures of the stars surrounding β Cygni showed certain discordances which seem to indicate the existence of a large parallax for this star.

The formal paper of the evening was then read as follows:

A Theory of the Formation of Lunar Craters.

BY G. K. GILBERT.

(ABSTRACT.)

The theory agrees with the meteoric theories of Proctor, Meydenbauer and others in that it ascribes the craters to the impact of bodies colliding with the moon. It differs as to the previous history of the incident bodies. It postulates as the antecedent of the moon an annulus of many small bodies surrounding and revolving about the earth as does the ring of Saturn about that planet. The components of this ring afterward segregated so as to constitute a smaller number of larger bodies, and finally a single body—the moon. The craters of the moon's surface, large and small, are the impact scars of those minor aggregates which were last captured by the moon.

After the moon had acquired approximately its present mass the velocity of impact for bodies of the system was about 7700 ft. per second. The energy due to this velocity, if converted into heat, was more than sufficient to fuse the colliding body, assuming that body to have the specific heat and fusing point of diabase. The impacts of small bodies seem to have produced deformation without fusion ; but in the impacts of larger bodies more energy was applied to each unit of surface, and parts of projectile and target were fused, producing the level plains of the larger craters. The recoil of the liquified and softened rock toward the centre produced the central hill characteristic of lunar craters. The corrugated rim of the typical lunar crater is due to outward thrust ; the inward facing cliff overlooking the inner slope, and the broken terraces below it, are due to land slips, a part of the rim falling back into the fused tract.

The round maria, such as M. Crisium and M. Serenitatis, are regarded as large craters, and the Caucasus-Appenine-Carpathian mountain chain as the remnant of a crater rim with a radius of 400 miles.

Certain parts of the surface are observed to be sculptured by an agency acting along lines which, for each locality, are nearly parallel. Grooves are plowed, crater rims are notched, and ridged additions appear to have been made to the surface. The same districts have been flooded by liquid and viscous matter, diminishing the depth of the larger craters, obliterating the small craters, partly filling cracks (rills), and afterward solidifying. In some low-lying districts the more liquid part of this matter collected, producing plains of the second order of magnitude and ever maria. The lines of sculpture of these districts radiate from a point in the Mare Imbrium. It is believed that the collision of a large moonlet at this place, under circumstances causing much fusion, hurled a deluge of molten and fragmental rock in all directions, flooding and partially remodeling a fourth part of the visible face of the moon. The central tract of the moon lies within the flooded area, and to this fact is ascribed the often noted contrast between its topography and that of the "honeycomb" district about the south pole.

The paper is to be printed in full in the Bulletin of the Philosophical Society of Washington.

Remarks were made by Dr. Bolton, Mr. Jacoby and Prof. Rees.

February 13, 1893.

Stated Meeting.

Biological Section.

A paper on the "Functions of the Internal Ear" was presented by Dr. F. S. Lee, based upon study of dog-fish. The results of experiments were given showing that the semi-circular canals are sensory organs for dynamical (rotational) equilibrium, otolithic parts for statical (resting) equilibrium. Each canal appreciates movement in its own plane, and by a definite functional combination of canals all possible rotational movements are mediated. This theory explains compensating movements of eyes, fins and trunks. The method of experiment was that of sectioning the branches of the acoustic nerve and stimulation (by rotational movements) of the swimming fish.

In a paper by Dr. Bashford Dean, on the Marine Laboratories of Europe, a series of views were shown of the stations of Naples, Banyuls, Roscoff, Plymouth, Arcachon, the Helder, and St. Andrews.

Prof. H. F. Osborn described the foot of *Artionyx*, the new member of the order Ancylopoda, Cope. It is distinguished from *Chalicotherium* by the character of ancle and pes, which present a marked resemblance to the Artiodactyla, while *Chalicotherium* represents these structures as found in Perissodactyla. Both genera are ungulate in ancle joint, but the phalanges terminate in claws, and in view of the double parallelism between these two forms and the two sub-divisions of Ungulates, it was suggested to divide the Ancylopoda into the Artionychia and Perissonychia.

February 20, 1893.

STATED MEETING.

Vice-President DR. BOLTON in the chair.

One hundred and fifty persons present.

MR. COURTENAY DE KALB, E.M., delivered a lecture, entitled "Three Thousand Miles Up the Amazon," illustrated by lantern views.

An the close of the discourse a vote of thanks was tendered the lecturer.

February 23, 1893.

SPECIAL MEETING.

SECTION OF GEOLOGY AND MINERALOGY.

President O. P. HUBBARD in the chair.

MR. KUNZ remarked a new discovery of topaz crystals from Palestine, Texas, and exhibited an electrotype of one. The crystals are being measured, and will be described in full elsewhere. MR. KUNZ also announced the discovery of a meteoric stone in Phillips County, Kansas, of unusual size.

The following papers were read :

A GEOLOGICAL RECONNOISSANCE IN THE VICINITY OF GOUVERNEUR, N. Y.

BY C. H. SMYTH, JR., HAMILTON COLLEGE.

Introductory.—Though noted for their minerals, the northern counties of New York have received little attention from geologists since first described by Emmons*. Indeed, the same may be said of most of the Adirondack region, of which these counties are, topographically and geologically, an essential part.

Questions in regard to the ages of certain formations have been discussed by Hunt†, Brooks‡, Hall§, and Walcott‖, while the iron ores have been described by Smock¶. But so much of the region remains practically undescribed that it does not seem out of place to present briefly some results of an examination of a limited area lying in the towns of Gouverneur and Fowler, St. Lawrence County.

Topography.—Throughout the region examined the relation between the geological structure and the topography is evident. The larger hills are composed of tough gneiss, while the valleys are excavated in limestone. The smaller elements of topography follow the same rule, the alternations of hard and soft strata inclined at high angles producing numerous short, steep ridges, trending northeast, in accordance with the general strike of the region. These ridges usually consist of bare rock and rise abruptly from flat meadows, which are often swampy. The maximum relief hardly exceeds four hundred feet, while the elevation above sea level reaches about eight hundred feet.

Glacial deposits are of limited extent and exert little influence upon the topography, as compared with the effects produced in more southern portions of the State.

The region is drained by the Oswegatchie River, a considerable stream, rising in Cranberry Lake, in the southern portion of the county. Below Gouverneur village the river's course shows a marked dependence upon rock structure, the stream flowing in several large loops roughly parallel to the strike.

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* Emmons, E., Geology of N. Y., 2d District.
† Hunt, T. S., 21st Ann. Rept. Regents University of New York, p. 88.
‡ Brooks, T. B., American Journal of Science iii., IV., p. 22.
§ Hall, J., American Journal of Science, iii., XII., p. 298.
‖ Walcott, C. D., Bulletin 81, U. S. G. S., p. 207.
¶ Smock, J. C., Bulletin 7, N. Y. State Museum.

The same trend is shown in the lakes north of the Oswegatchie, notably in Yellow and Black lakes, the former lying close to the river and exactly parallel to it. As would be expected, the glacial scorings have the same direction, and it is possible that the ice has been a considerable factor in cutting the valleys; but of this no proof is at hand.

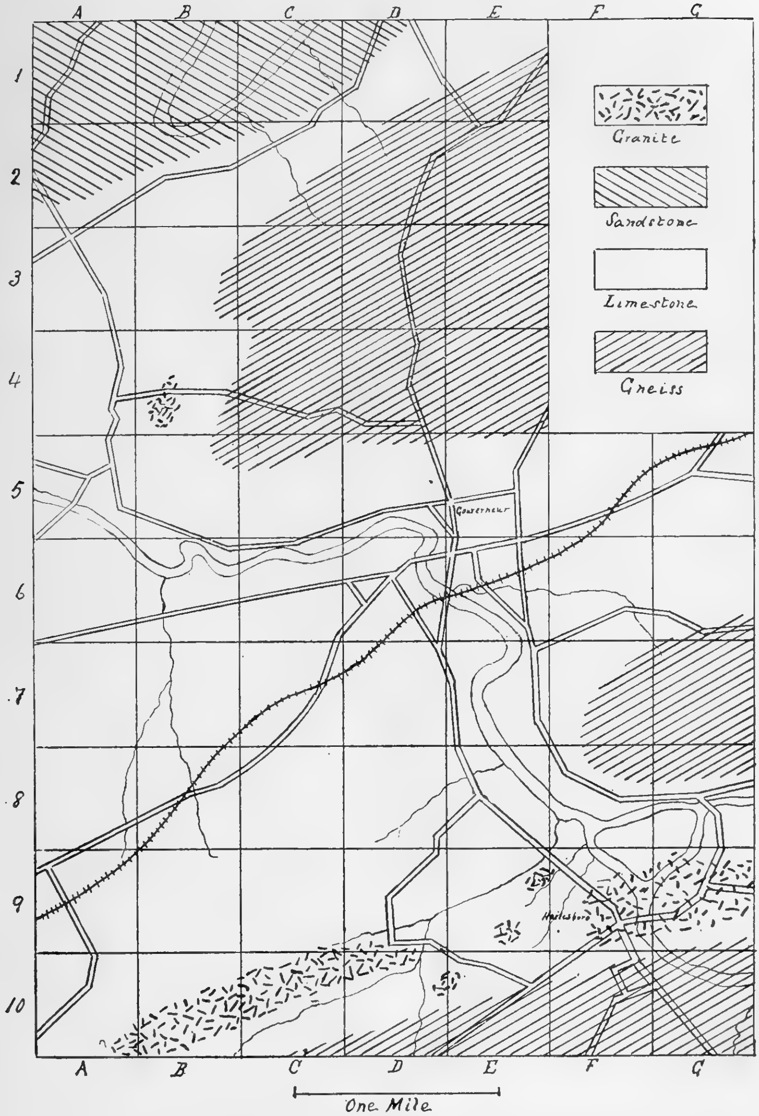
Rock Formation.—The rocks of the district are chiefly gneiss, limestone, sandstone, and granite; with which are associated limited amounts of iron ores, serpentine, pyroxenic schists, and hornblendic rocks.

The areas occupied by the four important formations are roughly outlined upon the accompanying map, which, though including only a small portion of the region examined, shows the most interesting localities.

Gneiss.—The gneiss forms the more elevated portions of the region and is the oldest of the rocks, underlying the other members of the series. It has no characteristics which distinguish it from the gneiss of the southern and western portions of the Adirondack region, unless it be a larger proportion of biotite, as compared with hornblende. The usual color is gray or red, but dark colored basic layers are not uncommon. Veins of quartz and of pegmatite are abundant, cutting the gneiss in all directions. Jointing is pronounced at many points. The hillside south of Gouverneur village shows a marked step-like structure, due to jointing. North of the village, at E 4, the gneiss shows a large number of small parallel joints, running at right angles to strike and dip, and separating the rock into thin layers. Along some of these joints slipping has occurred, causing miniature faults, with a maximum throw of two feet. These are exhibited with diagramatic perfection, as they displace a black hornblendic layer about one foot wide, enclosed in red gneiss.

The gneiss shows no very pronounced effects of weathering. The surface is often roughened by solution of the feldspar, the quartz remaining intact. Oxidation of iron sometimes gives a red or yellow tint, extending to no great depth. Where the rock is coated with moss, the surface layer of perhaps 5mm. thickness is commonly bleached to pure white by decomposing organic matter derived from the moss.

The banding and foliation of the gneiss are quite variable, being sometimes very pronounced, and again nearly or quite lacking. As they decrease the gneiss approaches, and sometimes passes into true granite. A particularly good example of



MAP OF THE VICINITY OF GOUVERNEUR, N. Y.

this is shown at B 5, where the strongly foliated gneiss passes by insensible stages into coarse red granite, showing no trace of banding or foliation. It is possible that the granite is younger than the gneiss, the gradual passage from one to the other being due to the finer grain of the intruded rock near the contact and the subsequent effects of dynamic metamorphism. But the transition is so gradual that this explanation seems improbable, and it is rendered more so by the perfect agreement in the mineralogical composition of the two rocks when examined under the microscope. It seems necessary to regard the gneiss and granite as different phases of the same rock. The cause of the difference may be explained in two ways: either the granite is an unchanged remnant of a plutonic mass from which the gneiss is derived; or it is a result of fusion of the gneiss by intense metamorphism. For a choice between these two explanations little evidence is at hand. It is, however, a fact that the gneiss of this locality shows unusually pronounced foliation, whence it would seem that metamorphism was strong here, and would be more likely to produce fusion than to leave a considerable area unaffected.

Limestone.—As shown on the map, a large portion of the region examined is underlain by limestone, which extends in an irregular belt many miles east and west. In age it is evidently next younger than the gneiss. This limestone is the source of most of the interesting minerals of the region, of which tourmaline, amphibole, pyroxene, scapolite, and serpentine are, perhaps, most common. But while these are developed only in certain localities, the limestone nearly everywhere has disseminated through it abundant scales of graphite and light brown mica, sometimes associated with grains of pyrite.

The rock varies from dark grey to white, and is always coarsely crystalline. Where large surfaces are exposed a distinct banding is often apparent, but in most outcrops this is not shown, and the rock presents such a massive appearance that it is impossible to make out the strike and dip. Thus, in spite of numerous outcrops, it is a matter of much difficulty to ascertain the thickness of the formation, and its relations to the underlying and overlying rocks.

The limestone is always greatly weathered, the most evident result being a gray to black surface coloration. When pyrite is present a yellow stain extends to some depth. Some curious effects have been produced by solution along the abundant joint planes, many outcrops being completely honeycombed in this way. A rounding of all edges and corners is invariably shown, and cavities often contain considerable quantities of rock fragments, in which the proportion of insoluble constituents is largely increased. Weathered surfaces often show many projecting lumps of silicates, which ultimately become entirely freed by solution of the surrounding rock.

Relation of Limestone to Gneiss.—From a stratigraphic standpoint one of the most important problems of the region is presented in the relation between the limestone and the gneiss. As is well known, Emmons* regarded the limestone as an igneous rock that had broken through the gneiss, which latter he held to be of undoubted sedimentary origin. Brooks† was led by his studies in Rossie to consider the limestone unconformable with the gneiss, and in this opinion the later investigators, with the exception of Hunt, seem to coincide.

The precise character of the relations between the two formations, however, cannot be definitely settled, until the true nature of the gneiss is determined. If the gneiss is a metamorphosed sedimentary mass, whose foliation and banding are identical with planes of deposition, it must be ascertained whether or no there is discordance between this foliation and banding and the the bedding of the overlying limestone. For several reasons it is difficult to procure exact data bearing upon this point. One of the obstacles is the massive character of the limestone; another the variability of the gneiss, making it impossible to tell whether or not the limestone is always in contact with the same horizon of this formation. A third difficulty lies in the rarity of contacts between the two formations. Thus, while a general parallelism in the structure of the formations is plainly apparent, it is not easy to decide whether or not there is true conformity. Such a parallelism might readily exist in unconformable formations, being the result of two distinct periods of folding in the same direction. But in spite of this general parallelism between the gneiss and limestone, two localities were found that showed a marked discordance, while at several other points this was strongly indicated.

This discordance between the bedding of the limestone and the foliation and banding of the gneiss may be general, but before it can be called an unconformity between sedimentary deposits the foliation and banding must be proved to be identical with sedimentary bedding. Until this is done two other suppositions must be considered as possible explanations of

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* Geology of N. Y., 2d District, p. 37 et seq.

† American Journal of Science, iii., IV., p. 23.

structure. Either the gneiss is younger than, and has been introduced into, the limestone, or else it is a metamorphosed plutonic rock, which formed the floor of the sea in which the limestone was deposited. The absence of anything like an irruptive contact between the two rocks at once excludes the first supposition, and therefore the gneiss has been called, without hesitation, the older rock. The second supposition, which has been already mentioned, is somewhat favored by the structural relations of the rocks. Regarding the foliation as a secondary feature resulting from pressure, it would naturally be parallel to the folds of the limestone, which are due to the same cause. The foliation may date from the same period of metamorphism as does the folding, or it may have been complete before the deposition of the limestone. But even in the latter event, it seems probable that the pressure of the second stage of metamorphism would act in the same direction as that of the first, thus leading to a general parallelism between the foliations of the gneiss and the bedding of the limestone.

This view of the gneiss as a metamorphosed plutonic rock seems to afford the simplest explanation of the facts thus far observed, but it cannot be accepted even conditionally until sustained by much more extended investigation. That some portions of the gneiss will prove to be of igneous, and other portions of sedimentary, origin, is extremely probable.

Schists.—Near the base of the limestone and imbedded with it are some peculiar schistose rocks, which outcrop near the gneiss, north and south of Gouverneur, and again in the village. These schists are variable in color, usually dark, and weather to a rusty color. They offer greater resistance to denuding agents than does the surrounding limestone, and, therefore, form low, steep ridges. Containing feldspar, quartz, biotite, hornblende, and augite, they somewhat resemble igneous rocks in composition, but their field relations indicate that they are of sedimentary origin, and have been subjected to metmorphism sufficiently intense to produce complete recrystallization.

Sandstone.—Overlying the limestone is a heavy mass of sandstone, often so much indurated as to be better called quartzite. The color varies from yellow to red, and the grain from very fine to that of coarse conglomerate. The rock outcrops in prominent ridges on both sides of the river, three miles north of Gouverneur, and extends several miles east and west, but was not traced to a limit in either direction. It is composed chiefly of quartz, with a little mica, and varying quantities of ferric oxide. The latter is sometimes so abundant that that the rock has been mined as an iron ore.

Where much folded, the sandstone often has the appearance of a breccia, made up of thin, angular fragments. On close examination, these fragments prove to be bits of sandstone, and the brecciated character is seen to be due to a shattering of the rock by pressure, as stated by Emmons*. It is easy to find every stage between the unchanged rock and that which has been reduced to small fragments, recemented by subsequent infiltration.

Comparing this result of pressure with that produced by the same cause in the limestone, a marked contrast is presented. In the sandstone the effect is largely mechanical—a breaking of the rock. In the limestone, chemical changes and crystallization are the prominent result.

Crossbedding on a large scale is very conspicuous in the sandstone, often obscuring the true dip. Concretions also are abundant in some localities, two apparently distinct kinds being found—small spherical and large cylindrical. The former have been mentioned by Brooks†, the latter by Hough‡. The small concretions resemble closely those that are found in many other formations, but the large ones are peculiar. Of cylindrical form, one to twenty feet in diameter, and perhaps six feet, they usually stand perpendicular to the bedding, and their appearance is striking. The material of the concretions does not differ from that of the surrounding rock, and the causes are obscure, which explain why it should be arranged as it is, in successive layers, concentric about a line. The age of the sandstone was stated by Emmons to be Potsdam, and such it has been always considered by later writers. Though no fossils have been found in this immediate vicinity, there seems to be no reason for doubting the correctness of this view.

Relation of Sandstone to Limestone.—There is some confusion in Emmons' discussion of the relation between the sandstone and the limestone. He classes the limestone as primitive and yet plainly implies that it is younger than the sandstone. For he describes disturbance and contact metamorphism in the sandstone produced by the supposed intrusion of igneous

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* Geology of New York, 2d District, page 104.

† American Journal of Science, iii., IV., p. 25.

‡ Hough, F.B., 3d Ann. Rept. Regts. Univ. N. Y., p. 32; also Amer. Association Proc. IV., p. 362.

limestone*. In another place† he speaks of the sandstone as lying unconformably upon the primary.

Brooks was led by his observations in Rossie, to conclude that the limestone was conformable with the sandstone‡, and, therefore, of Lower Silurian, or, as it would now be called, upper Cambrian age. The data upon which Brooks based his conclusion seems to the writer unreliable ; for at Rossie the limestone and sandstone are separated by considerable bodies of iron ore and a peculiar serpentine rock of doubtful origin. Until the true character of this member of the series is ascertained, it is unsafe to base conclusions upon observations made at that locality.

North of Gouverneur the limestone and sandstone are in direct contact, and opportunity is afforded for a study of their relations. The evidence here presented, though often obscured by the character of the rocks, indicates unconformity. From the irregular line of contact it is clear that the material of the standstone was deposited upon a limestone surface that had been subjected to erosion. An interesting confirmation of this conclusion is seen in the presence of narrow, irregular cracks extending several feet into the limestone and filled with sandstone. Evidently the limestone was completely lithified, and not a calcareous ooze, when the sandstone was deposited upon it, and this implies discordance.

This unconformity proves only that the limestone is older than upper Cambrian. For any more definite determination of its age the data are wanting.

Granite.—In the southern part of the area examined granite forms a prominent ridge extending east and west. Besides this main mass, there are many small patches breaking through the limestone, some of these consisting of a pegmatitic variety. Emmons' theory of the igneous origin of limestone was largely based upon the character of the contact between the main body of granite and the surrounding limestone. He regarded the granite as a massive phase of the gneiss, and, holding the latter to be sedimentary, was forced by the undoubted irruptive contact between granite and limestone to look upon the latter as igneous. Were the identity of gneiss and granite a fact, a ready explanation of the origin of the former would be

* Geology of N. Y., 2d District, p. 53.

† Fourth Ann. Report, Geol. Survey of N. Y., p. 322.

‡ American Journal of Science, iii., IV., p. 22.

afforded. But such is not the case; they are entirely distinct, the granite being younger. This conclusion is not based upon actual contact relations between the two rocks, for no contact was found. But it is believed that the marked difference in petrographic character and degree of metamorphism affords sufficient evidence for regarding the formations as distinct.

The granite of the main ridge was traced, with occasional breaks, over a distance of ten miles, without reaching a limit. The height of the ridge varies from nothing up to two hundred feet, the width averaging perhaps a quarter of a mile. A peculiar topographic feature is presented in the presence of several basins in the ridge, partially enclosed by precipitous walls and with flat meadow bottoms. These may represent masses of limestone, that have been weathered out from the surrounding granite.

The village of Hailesboro is built upon the granite and affords a favorable locality for its examination. In the angle between the creek and highway, E 9, a low hill of granite shows well the general character of the rock, together with a peculiar modification. The average rock is a coarse grained aggregate of quartz, white feldspar, and biotite, the latter constituent varying greatly in quantity, and often entirely absent. No muscovite has been seen, even of secondary origin, and the rock must, therefore, be classed as a granitite. Gneissoid structure is seen in a few areas of limited extent, but is not so marked as at some other localities. Near the northern edge of the outcrop the granite shows a fine grained, white phase. This crumbles under the hammer and looks much like a white sandstone, though showing no parallel arrangement of constituents. Microscopic examination shows it to be a fine mosaic of quartz and feldspar, with numerous coarser grains of garnet, often with crystal outline. That this rock is simply a peculiar phase of the granite is shown by the passage of one into the other by imperceptible stages. This modification of the granite, which may be distinguished as granulite, occurs at many points in the region, and always shows the same gradual transition into ordinary granite. Several patches of dark silicates enclosed in the granite, being sharply separated from it and made up chiefly of hornblende, are presumably inclusions brought up from deep-seated rocks. Quartz veins are abundant, and represent at least two periods of fracturing and infiltration. This outcrop also shows well the contact with limestone. The granite breaks through the limestone causing great disturbance of strike and dip, and completely enclosing masses of the rock many feet in diameter. The effects of contact metamorphism are not as conspicuous as would be the case in a non-crystalline limestone. Still, there is a whitening of the limestone and an increase in the amount of silicates, while the graphite scales become much larger than usual.

In the river gorge at Hailesboro the granite is very micaceous and dark colored, and at the lower end of the gorge becomes decidedly gneissoid. The same transitions into granulite and non-micaceous varieties are also shown.

West of Hailesboro there is a break in the granite ridge where Matoon Creek flows, and beyond this, about two miles from the village, the rock shows a gradual transition into a very dark variety which has the mineralogical composition of a diorite though perfectly continuous with the main body of granite. Several alternations between the ordinary granite and the more basic phase, are seen in this vicinity. There are also many dikes of pegmatite, which may be regarded as the complement of the basic masses, the two together illustrating well the tendency towards differentiation of rock magmas, which is such a potent factor in the development of igneous rocks.

The small bodies of granite which are scattered over the region sometimes resemble closely the granite of the main ridge, but oftener are coarse aggregates of quartz and feldspar. Sometimes the grain becomes finer, and they assume the character of graphic granite. The ordinary granitite always occurs in the form of irregular bosses, but the pegmatite, both as bosses and as sharply defined dikes, cutting either gneiss, limestone, or granite. The pegmatite masses are usually of limited extent, but at B 4 there is an outcrop covering several acres. The rock here shows, what is not uncommon elsewhere, considerable tourmaline very irregularly distributed, and occasionally some mica. This outcrop exhibits a perfect irruptive contact with the limestone, like that of the main body of granite described above.

The pegmatites often show traces of metamorphism in the production of incipient foliation, and the shattering of small rock masses.

Mechanical Effects of Metamorphism.—Attention has already been given to certain mechanical effects of metamorphism, in speaking of gneissoid structure and the brecciated sandstone. But some other instances seem of sufficient interest to merit description.

At the corner of Clinton and Barney streets, in Gouverneur, is an outcrop of limestone containing abundant fragments of a nearly black schist. These fragments constitute, perhaps, one-third of the rock mass, vary in diameter from one-quarter of an inch to two feet, are decidedly angular, and are scattered through the limestone in the most irregular manner possible. At first glance they might be taken for abundant inclusions in a light colored igneous rock, and it is strange that Emmons did not mention the occurrence in support of his theory of the igneous origin of limestone. Examination of other outcrops of a similar nature shows that the schist fragments are the remains of once continuous sheets, either interbedded with or intruded into the limestone, which have been completely shattered in the course of metamorphism. Between extreme cases, like that described, and those where the schist is but slightly distorted, there is every possible stage. The schistose layers pass from gentle folds into the most elaborate contortions, in these the schists are often stretched apart, their edges on each side of the break being drawn out to thin wedge shape, sometimes with a few flattened lenses partially connecting them. Complete obliteration of the original continuity is rather exceptional. A peculiar feature of this distortion and fracturing, is that the limestone shows almost no trace of it. It has the appearance of a plastic mass in which the schists could move with considerable freedom. The conspicuous result of metamorphism in the limestone is crystallization, and this has obscured the mechanical effects.

The true character of the schistose rocks is often greatly obscured by this contortion, with the accompanying mineralogical changes; and it is sometimes very difficult, or even impossible, to decide whether they are interbedded strata or intrusive sheets. The smaller masses of pegmatite have been much shattered, and are often reduced to small lumps of quartz and feldspar, scattered through the limestone. But so far as observed, the pegmatite yields to strain only by fracturing, and never shows the preliminary contortion that is so general in the schistose layers.

Date of Metamorphism.—A comparison of the different formations serves to fix the time of metamorphism only in the most general way. It leads to the conclusion that the most intense metamorphism, which produced such marked changes in the limestone and associated rocks, occurred before upper Cambrian time. A second stage of metamorphism is recorded in the sandstone, and must therefore belong to post-Potsdam time.

In conclusion, it may be added that the writer hopes to do further work in the neighborhood of Gouverneur, as well as in other portions of the western Adirondack region. A second contribution on the petrography of the region will shortly follow.

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ON PHOSPHATE NODULES FROM THE CAMBRIAN OF SOUTHERN NEW BRUNSWICK.

BY W. D. MATTHEW.

INTRODUCTION.—Nodules and beds of phosphatic material are best known in the Cretaceous and Tertiary formations, but they also occur in many places in strata of Cambrian and Silurian age. The deposits of these older rocks are sometimes of economic importance, and are always interesting, both on account of the various theories of their origin, and because they are generally considered as due, directly or indirectly, to organic life.

To account for the little changed phosphate deposits of the Cretaceous and Tertiary, has proven a matter of no small difficulty, and many hypotheses, more or less plausible, have at different times been advanced. With the older deposits there is even greater difficulty, because they are usually so altered that their original structure is pretty well obliterated.

DIVISION OF THE SAINT JOHN GROUP.—Those described here are from the St. John Group of Southern New Brunswick, a series of gray slates, shales, and sandstones, mostly of Cambrian age, which formerly filled the bottoms of a number of long, parallel, northeast and southwest valleys, but which have been mostly swept away or covered by later deposits, except in the southern one, near the western end of which the city of Saint John is situated. The St. John Group is divided as follows :

DIVISION 1, OR ACADIAN STAGE.

a. Coarse gray sandstone or quartzite.
b. Coarse gray sandy shale.
c. Fine gray and dark gray shales.
d. Fine dark gray carbonaceous shales.

DIVISION 2, OR JOHANNIAN STAGE.

a. Coarse gray slates with thin seams of gray sandstone.
b. Coarse gray slate and gray flagstone, the latter predominating.
c. Gray flagstone and gray slate, in frequent alternations.

DIVISION 3, OR BRETONIAN STAGE.

a. Black shales alternating with dark gray shales.
b. The same as the last, but finer.
c. Black carbonaceous shales.
?. Same as the last, fauna unknown.
d. Similar shales, with a few sandy seams.

In Band *b* of Division 1, has recently been found a considerable fauna of Lower Cambrian age. Bands *c* and *d* of the same division contain the Paradoxides or Middle Cambrian fauna, while Division 2 and part of Division 3 appear to correspond with the Upper Cambrian of the United States. The upper part of Division 3 is of Lower Silurian age.

Occurrence of the Nodules.—The phosphate nodules occur at Hanford Brook, near the eastern end of the southern basin, in Division 1*b*, which is here subdivided into the following zones :

1.	Dark gray sandstone, - - -	40 feet
2.	Dark gray sandy shales, - - -	50 "
3.	Hard, purple streaked gray sandstones,	30 "
4.	Olive gray shale, - - - -	30 "
5.	Gray sandy shale, - - - -	20 "

In Zone 2 there is a layer of nodules about 2″ thick, and they also occur scattered through the hard sandstones of Zone 3. They are of considerable importance to the palæontologist, as it is chiefly in and near them that the Lower Cambrian fossils have been found.

Description.—The layer in Div. $1b^2$ consists of small, round or oval nodules, averaging about ½″ in diameter, black and comparatively soft, and set in a matrix of soft, green, coarse-grained sandstone, which fades out irregularly into the finer gray sandy shales. Those of Div. $1b^3$ are larger, more irregular in shape, and much harder, and do not break out of their matrix as do the smaller ones. The latter have almost always a trilobite test, or a number of trilobite fragments, at or near the centre ; the larger ones are generally barren of trilobites, though such as do occur in this zone are mostly associated with them. These nodules are conspicuously seen on the surfaces of the great blocks of sandstone which have fallen down from the steep bank of the brook ; they are also, however, sparsely scattered all through the mass of the rock, and in the upper part are more numerous, and are often fused and run together in masses of larger size, up to 3″ or 4″ in diameter.

The green sandstone which accompanies the nodules is also met with at Hanford Brook, in the Basal or Etcheminian series of rocks underlying the St. John Group. In Division $1b^2$ of the latter it is found as an irregular layer 2″ to 4″ thick, with fine gray sandstone on one side, and the layer of nodules, followed by a thin seam of fine shale, on the other. Only loose blocks were exposed at this point, the bed-rock not being accessible, and hence the actual position of the layers could not be determined. In Div. $1b^3$ the green sandstone is found in spots and patches scattered through the lower and middle part, and at the top makes an irregular bed averaging some 6″ thick as far as exposed ; but there may be considerably more. It is accompanied by hard phosphatic nodules, and with them contains what few fossils are found in this zone.

The nodules of $1b^3$ have been mentioned by G. F. Matthew, in connection with others occurring higher up in the series, near the city of Saint John, and have been considered to be probably coprolites, due to some large soft-bodied animal.

APPEARANCE IN THIN SECTION.—When examined in thin section under the microscope, the nodules of Zone 2 are seen to be composed of an amorphous, flocculent or granular, light brown substance, which, judging, from the analysis of the nodule, is probably a mixed phosphate of lime and iron. It is full of fragments of tests of Protozoa, apparently of more than one kind ; some look like Foraminifera, others resemble very much the microscopic bodies occurring in supposed sponge-rock from Caton's Island on the St. John River, and which have been described* under the name of Monadites. These may be gemmules of sponges. Besides these, there are seen in the sections three-rayed bodies, which may be spicules of lithistid sponges ; and here and there is a section of a much larger test having the outline of a crustacean, and which may generally be referred to Protolenus†, which is almost the only fossil, not microscopic in size, found in this seam.

The tests are for the most part preserved in calcite, but often also in chalcedonic quartz, and sometimes in a pale yellow, highly refracting mineral, which shows an aggregate polarization in low colors. This may be a variety of phosphorite. The more perfect tests are, when complete, usually filled with calcite, less often with glauconite or the pale yellow mineral just mentioned. When partly broken, they are generally filled by

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*G. F. Matthew, "On Cambrian Organisms in Acadia," in Trans. Roy. Soc. Canada, Vol. VII., Sec. IV., p. 147.

† A genus created by G. F. Matthew, in Bull. Nat. Hist. Soc. N. B., p. 34, to include a number of allied forms of Olenoid trilobites of Lower Cambrian age.

the flocculent, light-brown material, containing fragments of other tests. The trilobites are preserved either in calcite or the brown phosphate, with usually a dark line or band at the edges, to which, doubtless, is due the black, shining surface which they show when broken out of the rock.

The foraminifera are many chambered, with the cells grouped apparently much like *Globigerina;* but they are not perfect enough to determine exactly. The smaller bodies referred to *Monadites* are numerous, and of three forms—round or oval, pear-shaped, and urn-shaped. They sometimes have two chambers, and rarely three. They show very often, long, straight or curved, slender spines, and also what seem to be stems on which they grew. (The spines very probably represent the whip of the flagellate infusoria, to which sponge-gemmules have been referred.)

Towards the surface of the nodule, the brown phosphate becomes more dense, and an opaque ring sharply separates it from its matrix. Sometimes the central part is darker, and separated from the outer zone by a similar dark ring; or it may be distinct on one side, and fade out into the lighter part on the other.

The matrix may be of the same phosphatic material, but is more generally of glauconite grains, mixed with small angular fragments of quartz. Its coarseness then contrasts strongly with the fine grain of the phosphate. The glauconite is in irregular masses, averaging $\frac{1}{25}''$ in diameter, and often appearing as if made up of a number of small coalescing grains. Smaller round or oval grains are also common.

The gray sandy layers are composed of small grains of quartz and plates of mica, the latter almost always lying in the plane of bedding. In the fine shale there is an abundant groundmass, probably argillaceous, and comparatively few of the larger fragments.

The nodules from Zone 3 are rather different from those of Zone 2, and show considerable variety in structure. The mass of the sandstone is made up of angular fragments of quartz, and more rounded ones of calcite, with a fine dark-colored cement, more or less ferruginous. Near the nodules, grains of glauconite almost entirely replace the quartz, the calcite still being abundant. Sometimes each grain is coated with a thin dark layer of phosphate, and the cement is largely or entirely the flocculent phosphate.

The nodules themselves are much less pure than those of Zone 2, and contain much foreign material, mostly minute plates and shreds of mica. The large grains of quartx and calcite, however, are almost entirely absent. A bedded structure is sometimes noticeable in the arrangement of the mica. Protozoan tests or sponge gemmules complete enough to recognize are rare ; only two or three were certainly observed. Larger tests are more common, some referable to trilobites or ostracods, others appearing in the section as narrow straight rods, preserved in silica, often with a layer of phosphate at the edge. Innumerable minute fragments preserved in calcite are very likely comminuted tests of protozoa.

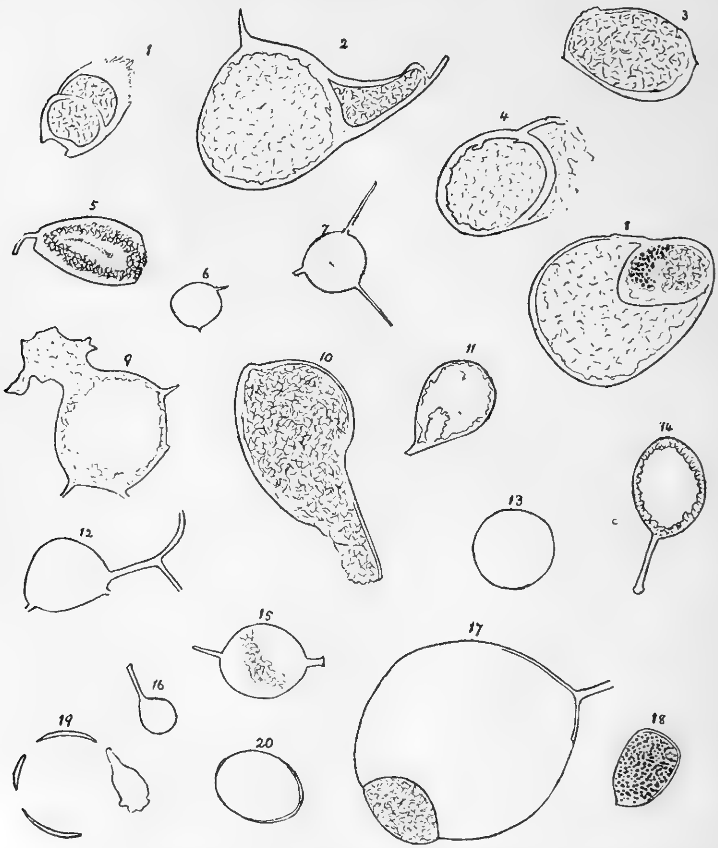

PLATE 1. Most of these appear to be *Monadites*. Figs. 2 and 8 may be foraminifera, and also, perhaps, Fig. 10.

The outlines of these nodules have little regularity ; they are, as a rule, flattened in the direction of the bedding. Usually they have the same distinctly marked surface as those in Zone 2, but occasionally they fade out into the surrounding sandstone.

In the accompanying figures are shown some of the most perfect of the small bodies in the nodules of Zone 2. The first three plates represent those referred to as perhaps gemmules of sponges (*Monadites*), and the supposed Foraminifera. The last plate contains the most distinctly outlined of the forms which can be considered as sponge spicules—though some, if not all, of these may be sections of broken tests of foraminifera or *Monadites*. In the lower part of this plate are shown the shapes characteristic of the glauconite grains.

The calcite which usually fills the interior of these bodies, and

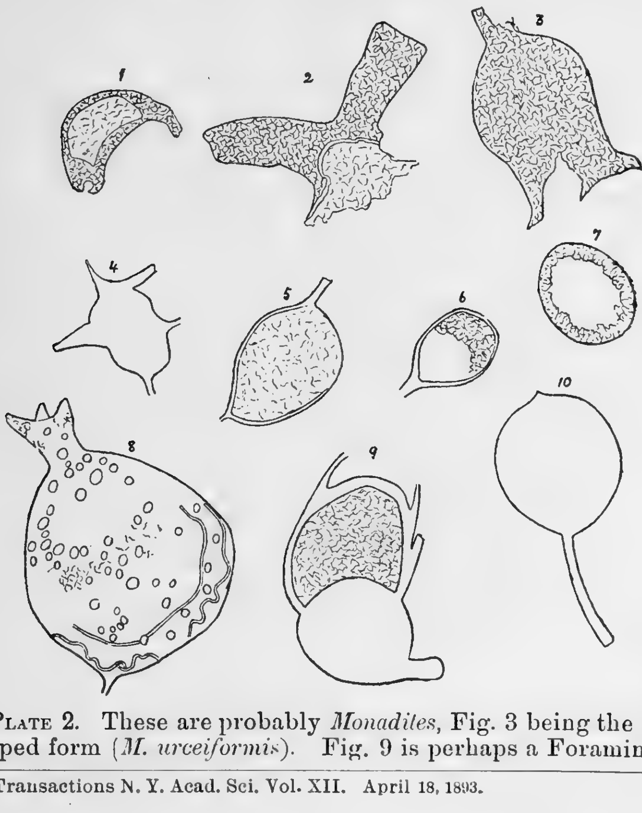

PLATE 2. These are probably *Monadites*, Fig. 3 being the urn-shaped form (*M. urceiformis*). Fig. 9 is perhaps a Foraminifer.

often constitutes their walls, is left unshaded ; the light yellow phosphorite is indicated by a faint shading, and the brown amorphous phosphate by a darker shade. In a few of the bodies, minute round grains of carbonaceous matter also occur, though the general absence of any organic matter visible to the eye is rather remarkable, considering the abundance of fossils in this seam, and the little altered character of the beds.

The identification of the figures, as far as made, is by my father, G. F. Matthew.

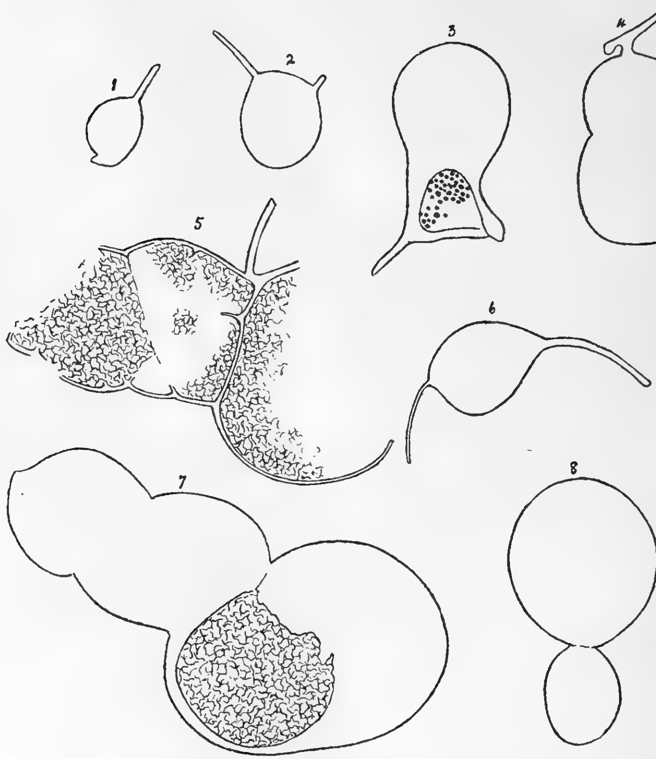

PLATE 3. Figs. 5, 7, and 8 are probably Foraminifera. The rest are *Monadites*.

Plate 4. Sponge spicules?, and glauconite grains. These, like all the preceding, are from Division $1b^2$ at Hanford Brook, and are enlarged 42 diameters.

A chemical analysis of the nodules from Div. $1b^2$ gives the following results :

SiO_2	24.74
Al_2O_3	11.85
Fe_2O_3	11.44
CaO	22 35
MgO	2.29
K_2O	0.59
Na_2O	1.41
P_2O_5	14.99
CO_2	3.53
Loss at 110°	3.43
Loss below red heat	3.44
	100.06

This shows an unusually large percentage of iron and alumina, and a low one of phosphoric acid. Much of the silica seems to be in the form of quartz or of silicates insoluble in acids.

OTHER PHOSPHATE NODULES IN THE ST. JOHN GROUP.—The only other occurrence of phosphatic nodules in the St. John Group is in Div. 2*c*, at the City of Saint John, where beds containing an abundance of Linguloid shells bear also irregularly rounded or flattened nodules of small size, which are composed of comminuted Lingulæ, and have been considered to be coprolites. The occurrence, shape, and composition of these are quite different from the Hanford Brook material ; they are black and shining, showing the little polished surfaces of the comminuted shells. They are not accompanied by glauconite sand.

COMPARISON WITH OTHER PHOSPHATE DEPOSITS.—Phosphate beds are well known in many other parts of the world. Those of the Cambrian and Lower Silurian of Wales, where one naturally looks for the nearest analogy to those of the St. John Group, have been described by Mr. Davies*, and their origin is discussed by Dr. Hicks† in an article on Phosphates in the Cambrian Rocks. They seem to be much more altered than those at Hanford Brook, but of much the same general character. They contain, however, a large amount of carbonaceous matter, and no mention is made of any glauconite accompanying them.

* Quart. Jour. Gol. Soc., London, Vol. XXXI., p. 357.

† Op. cit., p. 368.

Johann Moberg has recently* described a Cambrian fauna from sandstones in Sweden, containing glauconite layers. One type of a rock was a greenish, mostly laminated, fine-grained blending of light-colored quartz fragments, small white mica scales and glauconite grains, the two latter especially plentiful in certain layers. Another type was a fine light blue-gray sandstone, with abundant quartz, scattered glauconite grains, and calcareous cement. These rocks appear to be the same in character as the glauconite layers and quartzose sandstone of our Div. $1b^3$ at Hanford Brook. No mention, however, is made of phosphate nodules.

The presence of glauconite with the nodules suggests analogies to those found in the Cretaceous Greensands of England. These have been studied very thoroughly by Mr. W. Sollas†, Rev. Osmond Fisher‡, and others. In the presence of sponge spicules, foraminifera, etc., and in the glauconite accompanying them, they show a great resemblance to ours. But the form is different, being irregular or finger-shaped, with usually a hollow centre. The spicules are Hexactinellid, and seemingly much more numerous, and are often connected as if in place, which I have not been able to observe in any of ours. The English nodules are considered to be Ventriculite sponges, in which the organic matter has combined with and been replaced by phosphate of lime.

The Tertiary nodules of South Carolina are very variable in their character and, as mined, are mostly rolled and water-worn. They do not seem to be generally associated with glauconite. Some varieties contain abundant fossils, mostly shells ; others are dark and compact, with no fossils. With them are found great numbers of bones and sharks' teeth. They are generally irregular in shape, often in large flattened masses. Dr. Penrose§ considers that they are the result of the phosphatization of marly deposits, and that the nodular shape is due to the tendency of the phosphate to collect in concretionary forms. Dr. Shaler‖ considers that their most probable mode of origin was by the aggregation of lime phosphate at the bottom of swamps.

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*Om en nyupptäckt fauna i block af Kambrisk sandsten, insamlade af dr. N. O. Holst—Af J. C. Moberg (Aftryck ur Geol. Foren i Stockholm Förhandl., Bd. 14, Häft 2, 1892.)

† Quart. Jour. Geol. Soc., London, Vol. XXIX., p. 76.

‡ Op. cit., p. 52.

§ U. S. Geol. Survey, Bull. No. 46, p. 69.

‖ Op. cit., introduction.

The other deposits of phosphates known to me do not show very close analogies to ours, or are similar in their occurrence to those above mentioned.

ORIGIN.—The origin of the Hanford Brook nodules cannot be considered as decided by this investigation; but some consideration may be noted, bearing on what seem to be the most probable methods of formation.

The only one that has as yet been suggested for them is that they may be coprolites. In this case they must be referred to some animal much larger than any known from this formation; the animal might, however, as has been suggested by G. F. Matthew, have been soft-bodied, and hence not preserved, and there are indirect evidences of the existence in the Cambrian seas of some large soft-bodied animal probably related to the squids. But the trilobites found in the nodules are only occasionally comminuted; generally they are complete heads; occasionally complete bodies. In Zone 2 especially, but to some extent also in Zone 3, there is usually a nucleus which is sometimes a single trilobite test, sometimes two or three, or a number of fragments. The material collects rather on the inner side of the test than on the outer. Were the nodules coprolites, one would expect to find the tests thoroughly comminuted, and evenly distributed throughout the mass.

Another view, applicable especially to those of Zone 2, would consider them as fossil sponges which, like those of the English Greensands, have had their organic matter replaced by phospate of lime or iron. The occurrence of spicules and gemmules, the regular shape and uniform size, and the frequent presence of a central part of different tinge from the rest, indicating perhaps a cup-shaped or hollow centre' favor this view. The darker rim of the nodule is similar to that observed in those of the English deposits. The comparative scarcity of spicules and absence of any trace of canals, might be explained by considering the sponge to have had keratose or calcareous spicules, and to have been much decomposed and shrunken before phosphatization. Or there may never have been any canals, but only the central opening. The presence of the foraminifera and other foreign bodies might be explained by supposing them to have drifted into the openings after the death of the sponge. But the trilobites are not so easily accounted for, as they often traverse the nodules from side to side in a way that would seem inconsistent with the view of the latter being fossilized sponges, And they are not cup-shaped, as far as can be seen by the eye, but regularly round or oval; and it would seem as if the part of different tinge noticeable in some, is rather concentric with the rest than forming a core, or filling a cup-shaped hollow.

The presence of trilobite tests at the centre may indicate some form of concretionary or aggregative action, the material having collected around these as a nucleus. If this be so, three suppositions might reasonably be made:

1. That the material collected as gelatinous phosphate of iron and lime thrown down by ferruginous and calcareous waters coming in contact with phophoric acid liberated in the decay of organic matter.

2. That it originally collected as carbonate or iron and lime, but was converted into phosphate by the downward leaching of phosphatic waters passing through the sandstones and sandy shales.

3. That it was originally in the form of organic matter which was afterwards replaced by phosphate which formed a compound with it during its decay. In process of time the organic matter would disappear and the phosphate alone be left. The nodular form might have been its original structure, or, more probably, caused by the strong tendency of phosphatic deposits to assume such a shape.

The first hypothesis supposes that during the deposition of the seam in Zone 2, there was for a short time a stoppage in the deposition of sand, giving the phosphate time to collect and form a comparatively pure layer. The strong affinity of phosphoric acid for organic matter would cause it to collect, especially around the bodies of trilobites. The latter may have been also the principal sources of phosphorus, but were probably largely assisted by other organisms, minute or soft-bodied, and of the presence of which we have little direct evidence, except perhaps the glauconite. Iron phosphate is one of the most sticky and gelatinous precipitates that ever vexed the soul of the chemist, and appears to tend strongly to collect together in masses. The layer of fine shale next the nodule bed would indicate a rapidly decreasing influx of sediment, followed, perhaps, by a total cessation immediately afterwards, while the nodules were forming. Then there would seem to have been a period when the water was muddy and the sediment deposited rapidly, which, perhaps, caused the animals supplying the phosphorus to forsake that neighborhood. When they came in again with the clearer waters shown by the sandstone zone above, the phosphatic deposit recommenced. But it was not in quantity enough to form a bed, and only collected in scattered masses, which, suspended above the heavier sand, were mixed only with the finer particles in the water. When there was not enough phosphate to form nodules, it merely coated the grains of sand, or mingled with the mud which afterwards formed the cement of the sandstone.

The second hypothesis has been applied especially to the phosphate beds of South Carolina. The difficulty especially in the way of its application here lies chiefly in the regular shape and distinct boundaries of the nodules. These seem almost too regular to be due to the concretion of either carbonates or phosphates. Moreover, the entire absence of the coarser grains composing the rock around would seem to be against this theory. A second infiltration would seem to be required to explain the filling of the fossils with carbonate of lime unless for some reason this crystalline carbonate was not attacked by phosphoric acid. The impermeable layer of clay or mud in Zone 2 would, perhaps, serve to prolong the action of the phosphatic waters on the lime, and thus make a specially rich layer. In Zone 3 there was, perhaps, only enough phosphoric acid leaching through, to convert into phosphate such carbonate of lime as was in an amorphous and uncompacted condition, leaving the crystalline grains but little changed.

The replacement required by the third hypothesis has been shown to have very probably occurred in the Cretaceous phosphate beds of England, to which these deposits seem to be very nearly related. The apparent objections to its adoption have been already discussed.

With our present knowledge of the nodules, it is not easy to say which of these suppositions is the most probable one. Altogether, it seems very likely that they originated as organic bodies, or by some form of concretionary action. The large amount of iron is a somewhat unusual feature. I have come across only one or two analyses showing so high a percentage of iron, but iron phoshate is probably not uncommon in this form, though the deposits of economic importance are chiefly lime phosphate.

Further study of these beds will probably bring to light a large and interesting fauna, and will also, it is to be hoped, throw more light on this rather obscure problem.

Note on the Mode of Origin of the Paired Fins.

BY BASHFORD DEAN.

(ABSTRACT.)

Since the time of the observations of Balfour on the origin of the paired fins from continuous lateral derm folds, an extensive literature upon the subject has been steadily accumulating. At the present day it is very generally admitted that this mode of origin is well substantiated by embryological studies upon elasmobranchs, and in the "Gliedmassenskelet" of Wiedersheim the most recent view is given tracing from this primitive form the evolution of the various limb types, *Archipterygium*, *Actinopterygium* and *Cheiropterygium*.

It is especially interesting that within the past five years the actual primitive conditions in fin structure are coming to be provided by palæontology, and these now appear to directly confirm the conclusions obtained on the side of embryology. The earlier fossil fin structures can no longer be looked upon as in a measure supporting the archipterygial doctrine of Gegenbaur.

In a recent article Smith Woodward* has reviewed the evolution of fins in the light of his studies upon fossil forms, and shows how perfect is the evidence which reduces the structural characters of the paired fins to the type of the unpaired fins, on the ground of concentration and fusion of the supporting elements. These processes are first manifested in the basal parts and subsequently are produced into the rachis of the fin. The important contribution to the problem has been the structural characters in the pectoral and ventral of the Carboniferous Xenacanthids as studied by Fritsch, Döderlein, and Wiedersheim. In Xenacathids the pectoral is in all essentials dipnoan in character, while the ventral, always more primitive in structure, retains a typical monoserial archipterygium.

The most ancient form of fin suggested by these studies appears to be represented by a lateral derm fold not unlike the embryonic structure of sharks,—this was primitively strengthened by parallel hair-like rays, trichinosts, passing from body wall to fin margin, developed in close connection with ectoderm from mesoderm (Ryder). In this derm fold cartilaginous rays make their appearance, "radials," passing rod-like from fin margin to body wall, each of which is attached primitively to a similar

*Natural Science, March, 1892.

cartilage rod, "basal" firmly inserted in the body tissues; there may here be disregarded the questions of additional segmentation proximally and of the continuity of radials throughout the length of the fold. When concrescence takes place the basals become fused into a lateral horizontal bar of cartilage, more or less segmented in character; from this trunk of basals embedded in the body wall, the radials are seen to take their origin. This stage in the evolution of the fin is clearly suggested in the pelvics of Xenacanthids and in the almost as primitive pelvics of the cartilaginous ganoids, notably in *Polyodon*. The next stage of the evolution is represented by the gradual out turning of the trunk of the *basals*, whose posterior terminal comes to protrude from the body wall, and whose anterior end tends to become proximal. This out-turning of the basal fin stem brings with it a most important change in the functional capacity and indicates the point of divergence for specialized fin structures. Up to this point the entire fin was but a compressed remnant of the lateral fold, whose line of motion was little more than dorso-ventral. The protruding distal end of the trunk of basals now becomes the fin stem and as its motion becomes developed in many planes two prominent characters become evolved,—a tendency to concentration of elements about the distal fin stem, and second a growth of the dermal margin of the fin. The first causes the radials, which were formerly rod-like and parallel, to become so concentrated that extended fusions take place, and appears to be the cause of the jointed character that the rays now present, perhaps also of the branching and splitting structure of terminal elements, including doubtless those of the fin stem itself. The second character acquired by a fin in this evolution is the development concomitantly of a wide fin margin strengthened by dermal rays. The extended fin surface becomes doubtless of great advantage as the fin requires its additional movements,—and the formation, neomorphic (?), of light strong horn-like derm rays answers no doubt this requisite more fittingly then could a form of specialization of the cartilaginous radials. It would in fact appear in further evolution that the radials become reduced, encroached upon and outmatched in function.

A fin type represented by a jointed fin stem protruding from the body wall, articulating with the basals therein remaining, furnished on one side with a row of rod-like radials, is the actual condition in the pelvics of Xenacanthids, or cartilaginous ganoids. The radials are, however, becoming specialized; they become jointed and are tending to concentrate, fuse or split in the region of the distal fin stem. The derm margin of the fin has, in addition, encroached upon the older fin elements, and constitutes more than half of the fin surface.

The fin structure of the modern shark may readily be reduced to this type. Fusion in the radials has reduced these jointed rods to a compressed mosaic of polygonal plates,—the fin stem is consolidated into a basal cartilage band of three prominent elements, fore, middle, and aft. The dermal fin margin has greatly encroached, and the component rays have often grown and strengthened in the exposed (pre-axial) margin of the fin. In all of these specializations the ancient fin stem is coming to be directed caudad, and lies near the side in the direction of the axis of the body.

The evolution of the second type of fin is readily understood in the structure of the pectoral of *Xenacanthus*,—here the protruded and jointed fin stem has acquired in all essential characters the archipterygium of dipnoan and ancient crossopterygian;—the concentration and splitting of the radials is carried to its utmost specialization, the tendency to concrescence distally has caused them to spread around the fin tip and be carried proximally in their development on the opposite side of the fin stem; this itself in the process of concrescence has probably received distal increments. In this specialized type environment has had, doubtless, a large share in preserving the rigid axis in the middle of the fin, for uses which have been often alluded to in the case of *Ceratodus*.

While palæontology has rendered material aid in the understanding the mode of origin of shark and dipnoan fin structures, until recently it has afforded little clue to the still more primitive types. Smith Woodward has referred to a shark from the Ohio Waverly (Lower Carboniferous), described by Newberry and assigned provisionally to the genus "*Cladodus*," as exhibiting the most primitive fin structures extant. The paired fins he regards as functional remnants of the lateral folds, supported by nothing more than unjointed rods of cartilage passing from body wall to fin margin and apparently lacking in basal supports. He notes the significance of the concentration of the rays at the fore-margin of the pectoral fin, and in the absence of basal supports regards it as probable that in this region the concrescence, fusing, and splitting of the radial elements would give rise to an archipterygium.* In this view, however, Smith Woodward is directly opposed in a recent paper by Jaekel,† who had also examined the type specimens in the mus-

* L. c.

† Sitz. Ber. der Gesell. nat. Fr., Berlin, 1892, No. 6, p. 92.

eum of Columbia College. This author finds, in fact, that the fins of "*Cladodus*" afford no evidence as to lateral fold origin, asserts the presence of basal plates, and adduces the structure of the ventral fin to support his view as to the essentially modern character of the paired fins. The unique character of the body terminal as figured by Newberry, Jaekel regards as the restoration (in a graphite oil color) of the collector. While he emphasizes the modern structural characters he notes, however, the phylogenetic importance of the circum orbital ring of derm plates (Acanthodian).

At the present time discovery of new material by Rev. Wm. Kepler, of New London, Ohio, has enabled some of the structural characters of this interesting shark to be more critically examined. And in a paper, now in publication, the present writer has endeavored to consider the essential characters in their relation, particularly, to the doctrine of lateral folds.

It would appear in summary that this shark form (which the writer distinguishes from the *Cladodus* of Traquair, in which a monoserial archipterygium is present, by the new genus *Cladoselache*), presents the most manifest evidence as to the lateral fold origin of the paired fins. The fins, as stated by Smith Woodward, are actual remnants of the derm fold. The unjointed rod-like radials proceed from body wall directly to the fin margin ; the fin surface, therefore, is as yet lacking the specialization of the dermal margin and dermal rays. It would now appear that the basal plates exist but in a most primitive condition ; their fusion into a plate is seen to occur to a partial degree in the pectoral fin, but the rotation outward of the posterior end of this trunk of basals does not as yet take place ; the entire fin stem is still imbedded in the body wall. In the ventral a most interesting condition occurs,—a more primitive arrangement would here very naturally be expected,—the *basals in the body wall are as yet unfused, and are represented by rod-like bars of cartilage*, which outwardly resemble basal joints belonging to the radials—and were, in fact, so interpreted by Jaekel. The proximal ends of the basals are in actual process of concentration near the anterior fin magin ; the radials, however, are still more or less at right angles to the axis of the fish. Smith Woodward has already recorded one of the most significant features in the fin structure,--the marked way in which the radials are crowded together side by side in the *anterior* fin margin,—giving rise, in fact, in the pectoral to the specialization of a compact cut-water. The writer suggests that this tendency to compress the radial elements in the anterior fin margin could only occur when the line of the basals was still embedded in the body wall,—and would trace this conclusion still further to account for the anomalous fin spines of the Acanthodians. In *Parexus*, for example, it would seem quite clear that the broad fin spine is structurally compound, and may well represent the fusion of the radials in the anterior fin margin.

It may, in passing, be noted that the museum of Columbia College has acquired one of the specimens of Dr. Kepler, which sets at rest the objections of Jaekel as to the character of the body terminal. In the former specimens this, as now known, represented the vertical projection of the tail region,—the tail itself being edgewise is represented only in the acutely pointed apex. The tail structure, as shown in lateral aspect, proves to be broadly heterocercal, and is especially remarkable in lacking hypural supports to the upper lobe. This is strengthened epurally by a cut-water plate formed of the clustered elements. The tail structure is in many regards Acanthodian.

In the ventral of *Cladoselache*, the writer concludes, is represented the most primitive condition hitherto known in the ontogeny of the paired limbs. The fin is still outwardly a body derm fold, thrice as long as broad, blunted anteriorly where the radials are begining to be clustered ; the basal supports, in number, scarcely less than the appended radials, are still unfused although the process of concentration anteriorly is clearly to be marked.

February 27, 1893.

Annual Meeting.

The President, Dr. Hubbard, in the chair, and about forty persons present.

The minutes of the meeting of January 30th were read and approved.

The chairman of the Audubon Monument Committee made a report of progress which was accepted and committee continued.

The Treasurer, Mr. Henry Dudley, submitted the following statement for the year 1892–1893.

NEW YORK ACADEMY OF SCIENCES IN ACCOUNT WITH HENRY DUDLEY, TREASURER, 1892–1893.

Expenditures.

Janitorial Services	$ 126.50
Salary of Recording Secretary	400.00
Expenses of Recording Secretary	64 07
Treasurer's Expenses	21.25
W. R. Jenkins, printing cards, etc.	83 30
J. W. Huff, Printing Annals, etc.	1,180.09
Prof. N. L. Britton, Treasurer of the Audubon Monument Fund	50.00
Council of the Scientific Alliance.	71.81
Insurance of Printed Matter	20.00
Deposited in Institution for the Savings of Merchants' Clerks to credit of Library Fund	100.00
Balance	268.53
	$2,385.55

Receipts.

February, 1892, Balance from last year	$ 179.55
From Sale of Publications	52.00
Initiation Fees	70.00
Life Membership Fee	100.00
Fellowship Fees	20.00
Annual Dues of Members	1,750.00
Interest on U. S. 4 per cent. Reg. Bonds	152.00
" " " " Coupon Bond	12.00
C. H. Coffin for Audubon Monument Fund	50.00
	$3,385.55

Investments.

U. S. 4 per cent. Registered Consols	$3,800.00
" " " Coupon Bonds	300.00
Institution for Savings of Merchants' Clerks, Publication Fund	1,620.45
General Fund	1,081.00
	$6,801.61

REPORT OF THE RECORDING SECRETARY FOR THE YEAR ENDING FEBRUARY 27TH, 1893.

During the year there have been :

9 Meetings of the Council,
35 Meetings of the Academy, including
7 Public Lectures, and
7 Meetings of the Section of Astronomy,
5 Meetings of the Section of Biology, and
3 Meetings of the Section of Geology and Mineralogy.

The average attendance at meetings exclusive of public lectures has been 21 persons.

Forty-nine formal or announced papers have been read on the following topics :

Astronomy, 7	Geology, 4.
Botany, 4	Mechanics, 1
Biology, 7	Microscopy, 1
Chemistry, 7	Mineralogy, 5
Electricity, 2	Palæontology, 6
General Information, 1	Physics, 2

Zoology, 2,

besides seven papers read by title and a number of informal communications on a variety of topics.

Two new sections of the Academy have been formed. viz.:

The Section of Biology,
The Section of Geology and Mineralogy,

and the Section of Astronomy has been changed to the Section of Astronomy and Physics.

There are 233 Resident Members, including 75 Fellows.

During the year the Academy has elected

19 Resident Members,
3 Fellows,
7 Corresponding Members,

Fifteen members have been lost by death, resignation, etc.

H. T. Vulté,
Recording Secretary.

The following were elected officers for the year 1893–1894 :

President—H. Carrington Bolton.

1st Vice-President—J. A. Allen.

2d Vice-President—Henry F. Osborn.

Corresponding Secretary—Thomas L. Casey.

Recording Secretary—N. L. Britton.

Treasurer—Charles F. Cox.

Librarian—James F. Kemp.

Councilors—O. P. Hubbard, Harold Jacoby, A. A. Julien, D. S. Martin, J. K. Rees, R. P. Whitfield.

Curators—Bashford Dean, Arthur Hollick, G. F. Kunz, John Tatlock, Jr., H. T. Vulté.

Finance Committee—Henry Dudley, J. H. Hinton, Seth Low.

The following paper was then presented :

PROGRESS OF CHEMISTRY AS DEPICTED IN APPARATUS AND LABORATORIES.

BY H. CARRINGTON BOLTON.

(Abstract.)

From the very earliest times many arts were practiced involving chemical operations, such as working in metals, purification of natural salts for pharmacy, etc., dyeing of cloths and the preparation of pigments, brewing of fermented liquors, etc.; hence we find that long before chemistry became a science, even before it became inoculated with the virus of alchemy, furnaces and apparatus of earthenware, metal and glass, adapted to special work, were in common use.

The important adjuncts to laboratory utensils for the mechanical operations of pulverizing, grinding, sifting, etc., and the use of scales in a general way, date from the very beginnings of human industry ; these we disregard in the main and confine our study to apparatus more strictly adapted to chemical operations.

In tracing the progress of chemistry by reviewing the forms and variety of apparatus used at different periods, we do not attempt to establish definitely the date of introduction of a given instrument except in a few instances to be noted in their

places. To assign dates to the origin of apparatus that was universally employed before being specifically described is obviously impossible, especially since we shall depend upon drawings to illustrate the subject, and these drawings are commonly far more recent than the apparatus portrayed.

The Egyptians attained great skill in industrial arts at a remote period, and have left records of a most enduring character, pictures cut in their granite tombs and temples. There we see the processes of gold-washing and smelting; the use of blowpipes and of double bellows for intensifying heat, various forms of furnaces, and crucibles having a shape quite similar to those used to-day. Some of these crucibles preserved in the Berlin Museum date from the fifteenth century B. C.

Glass-blowing is a mechanical operation, but the preparation of the glass itself is a chemical process. The skill of the Egyptians in manufacturing glass is depicted on monuments of Thebes and Beni Hassan, and dates at least as far back as 2500 B. C.

Siphons for decanting wine, and on a large scale for draining land, were in use in the fifteenth century B. C. (Wilkinson).

The earliest chemical laboratories of which we have any knowledge are those that were connected with the Egyptian temples. Each temple had its library and its laboratory commonly situated in a definite part of the huge structure; at Edfoo the laboratory leads out of the Prosecus-halls. In these laboratories the priests prepared the incense, oils, and other substances used in the temple services, and on the granite walls were carved the recipes and processes; these are still to be seen by the archæologist.

The Israelites driven out of Egypt carried with them to the promised land knowledge of the technical and artistic skill of their contemporaries, and the Holy Bible contains frequent allusions to industrials arts. Cupellation is plainly described by Jeremiah, metallurgical operations by Job, Ezekiel, and others, and bellows by Jeremiah. This subject, however, I discussed in a paper read to the Academy April 12, 1892.

Geber, the Arabian physician and chemist of the eighth century, wrote very plainly of chemical processes, describing minutely solution, filtration, crystallization, fusion, sublimation, distillation, cupellation, and various kinds of furnaces and apparatus employed in these operations. Geber's works first appeared in a Latin translation from the Arabic at Strassburg, 1529; since then many editions in modern languages have appeared, but the drawings in all those I have seen are obviously of comparatively recent date.

Geber describes in detail the aludel (or sublimatory of glass), the descensory, apparatus for filtration, and the water-bath. This latter instrument, however, is said to have a more remote origin, having been invented by an alchemist named Mary, who is identified with Miriam the sister of Moses ; and the French name *bain-marie* is advanced as proof of this claim.

Perhaps the earliest drawings of strictly chemical apparatus are those in the so-called manuscript of St. Mark, which is a Greek papyrus on the "sacred art," preserved in Venice and recently edited by Berthelot. This embraces among other treatises the *Chrysopoeia of Cleopatra,* which dates from the beginning of the eleventh century. It contains, besides magical symbols, figures of distilling apparatus, the chief being an alembic with two beaks, resting on a furnace.

In manuscript No. 2327 of the Bibliothèque nationale, Paris, which bears the date 1478, are interesting drawings of furnaces, alembics, matrasses, receivers, etc., of glass, earthenware and metal. Some of them are copied from the manuscript of St. Mark. Professor Maspero, the Egyptian explorer reports the discovery by natives of the subterranean laboratory of an alchemist of the sixth or seventh century, at a point not far from Siout. This concealed laboratory contained a bronze furnace, the bronze door of another larger furnace, about fifty vases of bronze provided with beaks, some conical vessels resembling modern sandbaths, vases of alabaster, and gold foil of a low grade valued at over $350. In a corner of the dark chamber lay a heap of black, fatty earth that the workmen seized upon and carried off, saying they would use it to transmute copper ; "whiten" was their expression, but they evidenced a belief that this material was the "powder of projection" capable of changing copper to silver. This was in 1885. The substance on examination proved to be impregnated with some compound of arsenic, which would of course "whiten" copper.

The balance as an instrument of precision reached a high development under the Arabians as early as the twelfth century. The "Book of the Balance of Wisdom," written in the year 515 of the Hegira (1121–1122 A. D.) by al-Khazini describes minutely a water-balance of great ingenuity, and the specific gravity determinations of solids and liquids made by its aid are marvellously accurate. The author also describes a specific gravity flask of a practical make which he calls the "conical instrument of Abu-r-Raihan." This treatise, with its illustrations of the balances and the flask, I analysed in a paper read to the Academy in 1876. (*Am. Chem.*, May, 1876.)

In an interior view of a laboratory of the fifteenth century, by Vriese, very sumptuous appointments are seen ; a lofty room with tiled floor, furnaces on the right under an overhanging hood, an altar on the left before which the alchemist prays on his knees, in the centre a table covered with apparatus, books, and musical instruments, in the foreground an alembic, overhead a lamp swinging from a ceiled roof. The whole indicates wealth and luxury contrasting strongly with later pictures of the laboratories of impoverished alchemists.

The interior of workshops of alchemists of the sixteenth century have been artistically painted by the celebrated Flemish artist David Teniers. Of these interiors I am acquainted with six different styles, having, however, many features in common.

The alchemists, influenced by the atmosphere of mystical associations prevailing in astrology and the black art, affected fanciful names for pieces of apparatus bearing accidental resemblance to objects in nature ; the body of an alembic was a "cucurbit" or gourd ; an alembic-head without a beak was a "blind alembic"; if the beak was joined to the body so as to make a circulatory apparatus, it was a "pelican," owing to its outline resemblance to this bird ; two alembics joined by beaks were "twins"; a flask with a very long neck was a "bolt-head"; a flask with its neck closed before the blowpipe was a "philosophic egg." Again, the cucurbit surmounted by the alembic-head was symbolically called "homo galeatus," a man wearing a helmet.

A special form of furnace much extolled for alchemical operations was an "athanor," deathless, because the fire could be maintained indefinitely. The residuum of any distillation was a "caput mortuum," death's head. A cone-shaped bag for filtering was early known as "Hippocrates' sleeve"; the operating of closing a flask by fusing the neck was applying the "seal of Hermes"; fusing of two metals was their "marriage." A still more extravagant nomenclature was applied to chemical substances themselves, but of these and of the characters employed to designate them I have already addressed the Academy (December 11, 1882, and March 12, 1883). A single example will suffice. Basil Valentine wrote : "The greater the quantity of the eagle opposed to the lion the shorter the combat ; torment the lion until he is weary and desires death. Make as much of eagle until it weeps, collect the tears and the blood of the lion and mix them in the philosophical vase." That is to say : "Dissolve the substance and volatilize it."

In Iheronimus Brunschwick's *Liber de arte distillandi compositis*

(1500) are many coarse woodcuts representing distillations conducted under different planetary aspects ; also a noteworthy interior of a pharmacy of the fifteenth century, the apothecary's assistant busy with a pestle, gallipots on shelves, scales on a hook, and the licence and certificates of the master conspicuously displayed.

The remarkable and abundant illustrations of the operations of mining, treatment of ores by washing and smelting, in George Agricola's *De re metallica* (1556), are too well known to need mention.

The *Alchymia* of Andreas Libau (or Libavius), published at Frankfort in 1595, is conspicuous for accuracy of description and systematic arrangement of topics. He treats in this work of the *Encheria*, or manual operations, and of the *Chymia*, or substances, in separate books. The former he divides into two sections, one dealing with laboratory apparatus, and one with the construction and management of furnaces. He describes and figures an ideal laboratory provided not only with every requisite for chemical experimentation, but also the means of entertaining visitors, including such luxuries as baths, enclosed corridors for exercise in inclement weather, and a well stocked wine-cellar. This work, sometimes called the "First Text-book of Chemistry," contains woodcuts of a great variety of alembics having peculiar forms for special uses ; also a distilling apparatus fitted with an ingenious system of condensers for very volatile liquids. Besides the usual funnels for filtering Libavius describes the now neglected method of filtering by capillary fibres of wool or asbestus ; a process which, however, was known as early as 400 B. C., as I have shown in a paper read to the Academy, October 13, 1879. Filtration was often styled "destillatio per filtrum," and the method just named was known as "destillatio per lacinias ;" it is practically capillary siphoning.

Libavius' sumptuous plans were never realized, but towards the close of the seventeenth century the first public laboratory was opened at Altdorf (near Nuremburg) under Prof. John Moritz Hoffman. In the same year (1683), the first government laboratory was established by Karl XI. at Stockholm; of this the first director was Urban Hjärne.

A woodcut in a work published in 1570 depicts in a very interesting way all the steps in the manufacture of sugar, men chopping the cane, others grinding and pressing it, large cauldrons for boiling the juice, conical moulds in a frame, and the completed sugar-loafs.

Distilling apparatus in great variety is figured in the *Elixir vitæ* of the Italian author Donato d' Eremita, published in

1624. This pharmaceutical work contain nineteen full-page plates engraved with delicate skill.

In Kircher's *Mundus Subterraneus* (1665) are engraved numerous forms of furnaces and stillatories, largely copied from Donato d' Eremita's work.

J. J. Becher, in his account of a "Portable laboratory" (1719), exhibits on a single plate sixty-four different articles, including the following: Crucibles, muffles, cupels or tests, moulds for making cupels and for casting metals, mortars, mills for grinding, bellows, tongs, forceps, a tripod for supporting dishes, a rabbits-foot for brushing powders, a hand screen to protect the face from heat, various vessels of wood, copper, and iron, scales for weighing (three styles), retorts, phials, funnels, bladders, besides an apron, a towel, a linen jacket, an hour-glass, candles and tobacco-pipes!

Straw-rings for supporting round-bottomed vessels are pictured in Lefevre's *Traité* (1669).

The interior of the University laboratory at Utrecht, under the direction of Johann Conrad Barchusen, Professor of Medicine and Chemistry, is neatly figured in his *Pyrosophia*, published 1698. In this, as in others of the period, the prominence given to furnaces reflects the importance attributed to operations by fire.

Physical instruments of chemical application were slower in developing; thermoscopes appeared early in the seventeenth century and thermometers somewhat later.* Torricelli discovered the barometer in 1643, and Pascal tested its utility on the Puy-de-Dôme five years later.

Otto de Guericke's air-pump and frictional electric machine, together with the interesting experiments conducted with the Magdeburg hemispheres are handsomely depicted in his celebrated treatise *De vacuo spatio*, published in 1672. This air-pump and the hemispheres are preserved in the Royal Library, Berlin. The Hon. Robert Boyle improved Guericke's air-pump in 1659, and used it in laying the foundations of pneumatic chemistry, a field that from this time occupies our attention almost exclusively. Boyle's air-pump and accessory apparatus are figured in plates accompanying the several editions of his works.

As is well known the earlier chemists paid little or no attention to gases though they were familiar with processes which

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*Geber remarks that "Fire is not a thing which can be measured, therefore it happens that error is often committed in it." He evidently felt the need of thermometers.

generated them ; perhaps the study of gases was retarded by lack of inventive skill in handling them. Dr. Beddoes writing of Mayow, and reflecting on this point, uses the following language : "To be sensible of the merit of these contrivances of Mayow, we have only to recollect how difficult it must have appeared to confine, divide, remove from vessel to vessel, examine and manage at pleasure fugitive, incoercible and impalpable fluids like that which we breathe."

In 1672 Boyle obtained hydrogen gas by the action of acids on iron filings, and showed its combustibility, but seems to have made no attempt to collect and examine the gas.

The first scientific experiments in pneumatic chemistry were made by John Mayow, an Oxford physician, born in 1645 and died at the age of 34 years. In 1669 he published a work entitled *De sal-nitro et spiritu nitro-aëreo,* in which he figures his apparatus and describes his methods. To confine and study any gas, the air, for example, he inverted a cucurbit in a pan of water, used a siphon to establish the level of the water within and without, and introduced a shelf into the wider part of the cucurbit, from which he hung substances whose action he examined. He used a burning glass to ignite substances, camphor for example, placed in the cucurbit; he also introduced a mouse in a cage supported on a tripod under the cucurbit. He adopted an ingenious plan for transfering gases from one vessel to another, shown in the engraving that accompanies his rare treatises. Mayow failed to distinguish different gases, but was the pioneer in the method of manipulating them. Of his anticipating later theories of combustion we make mere mention, as our theme excludes theory.

Mayow's contrivances were somewhat improved by the eminent English botanist, Rev. Dr. Stephen Hales. In his "Vegetable Statics" (1727) he describes an attempt to analyse the air with many ingenious devices. Hales heated substances in a retort communicating by means of a siphon with a receiver consisting of a flask inverted in a vessel of water, the flask being supported by a cord from above. He heated nitre in this way, and especially noted the permancy of the air obtained, but failed to examine the properties of the air ; and he failed to differentiate the several gases obtained by his methods.

Even before Hales, however, an obscure physician in France, Moitrel d'Élément, had invented improved methods of handling gases. In 1719 he published a little pamphlet containing lucid instructions for measuring and collecting gases ; especially noteworthy is the separation of generator and receiver first suggested by him. The poor physician's skill was unnoticed by his contemporaries. In his old age a benevolent person took him to America where he died unhonored and unsung.

In 1757 Professor Joseph Black, of Scotland, determined the true characteristics of "fixed air," but seems to have made no important addition to the apparatus for studying gases.

In 1767 Mr. Peter Woulfe published a paper in the Philos. Trans. describing an improved apparatus for condensing vapors without loss and applied it to hydrochloric acid, ammonia, nitric acid, and other substances obtained by distillation. The apparatus still bears his name.

The prodigious advance made by Dr. Joseph Priestley in the manipulation of gases won for him the appellation: "Father of Pneumatic Chemistry." His prime invention was the insertion of a shelf into the vessel containing water, and the perforation of this shelf so as to admit of the gases ascending into receivers standing thereupon. This pneumatic trough is not mentioned by Priestley in his first chemical paper, published in 1772, entitled "Directions for Impregnating Water with Fixed Air." In this tract the accompanying figures illustrate his method of collecting the gases. A bottle for generating the carbonic acid, to the mouth of which is attached a bladder, and this in turn communicates with an inverted jar by a flexible "leather pipe sewn with waxed thread" and having quills thrust in both ends to keep them open. This simple apparatus was the forerunner of the modern soda-water machines.

In the first edition of Vol. I. of Priestley's "Experiments and Observations on Different Kind of Air," published two years later than the little treatise above noticed, the author modestly says "my apparatus for experiments on air is in fact nothing more than the apparatus of Dr. Hales, Dr. Brownrigg, and Mr. Cavendish, diversified and made a little more simple." He then describes the pneumatic trough, both for water and for quicksilver, the method of pouring air upward under water, the process of generating gases by heating substances in a gunbarrel, by aid of a burning glass in thin phials filled with quicksilver, and the way to pass an electric spark through gases in a jar over water or over quicksilver. This introductory chapter clearly shows the greatest progress in the manipulation of gases, and the way in which Priestley energetically applied his skill by the discovery of nine gases is well known to every student.

After the disastrous riots in Birmingham, July, 1791, in which Priestley's house and laboratory were wholly destroyed by an angry mob, an inventory was taken of Priestley's laboratory as a basis for damages. This inventory has been preserved and affords detailed knowledge of the material resources of the chemists of the period. It is divided into groups, philosophical instruments, electrical, optical, mathematical and chemical apparatus, with a small stock of substances, the whole footing up to the value of £605. The imperfections of some of the apparatus used by Priestley are shown by the fact that he experimented from December, 1782, to May, 1783, on the direct conversion of water into air by distillation only without the intervention of any other substance, to discover after all that this astonishing result was due solely to leaks in the porous earthen retorts employed in the process. The retorts, as well as other articles had been supplied gratis by Joseph Wedgwood; and Priestley, writing for more, desired to have them glazed within and without. (Scientific Correspondence of Priestley. New York, 1892.)

Scheele, the poor apothecary in a little village of remote Sweden, had to contend with obstacles sufficient to crush any but the bravest heart. With a few bottles, bladders, common dishes, and the simple appliances of a primitive pharmacy, this man of expedients accomplished wonders. Scheele's apparatus for generating oxygen was a simple retort, to the neck of which he tied a bladder. He was not acquainted with the pneumatic trough at the time of his chief discoveries. (Scheele's "Air and Fire," London, 1780.)

In 1796 James Watt, the English engineer, published an account of a simplified "Pneumatic Apparatus for Preparing Factitious Airs." In this is figured an "air-holder" made of tin-plate japanned inside and out, into which gas is conducted from the generating retort in a furnace, by means of a metallic tube bent at an angle of 45°, and terminating in the air-holder. Watt lays great stress on the advantages of inclining the "lower pipe," as stated, through Hales certainly anticipated him in this point. This pneumatic apparatus was manufactured by Boulton and Watt, at Soho, in two forms ; a large size sold for £10 2s. 6d, including auxiliary articles, and a portable apparatus for £3 15s. The pamphlet states that this apparatus are especially adapted for procuring "hydrocarbonate and oxygen air."

Meanwhile, across the Channel, in Paris, the opulent physicist and chemist, the unfortunate Lavoisier, enjoyed the advantages of highly specialized and admirably constructed apparatus of every description. An inspection of the plates in the *Traité élémentaire de chimie*" (1798) shows what a wealth of excellent utensils he had at his command. Two sketches by the pencil of Mme. Lavoisier introduce us into his laboratory while he is conducting experiments in the respiration of a man at work, and of a man in repose. After Lavoisier's legalized murder, an inventory of his laboratory was made by a government commission, among whom was the distinguished Nicholas Leblanc.

Accurate balances now became most important adjuncts to chemical laboratories.

Towards the close of the last century Italy contributed to chemical research two inventions of marvellous power—the Galvanic trough and the Voltaic pile, destined to electrify material human progress.

To sketch the development of chemical apparatus in this century would prolong this superficial review unnecessarily; modern appliances are distinguished by careful adaptation of the means to the end, and are improved by the introduction of coal-gas for heating purposes, by the use of india-rubber tubing and platinum vessels, and by the delicate products of the glass blowers' skill. To these features may be added novel contrivances for analytical chemistry, a field too recent to require elucidation.

[The paper was illustrated with 80 lantern views of the apparatus and laboratories described, including also exterior and interior views of the following institutions: Laboratories of the Museum in Paris, of Strassburg University, Bonn University, College of New Jersey, Kent Laboratory of Yale University, University of Michigan, Lehigh University, Cornell University, College of the City of New York, Woman's Medical College of the New York Infirmary, and School of Mines, Columbia College.

March 6, 1893.

REGULAR BUSINESS MEETING.

President BOLTON in the chair, and twelve persons present.

Messrs. L. S. FOSTER, of 35 Pine street, New York, and A. EUGENE CROW, of 2 West 53d street, New York, were elected Resident Members.

President BOLTON called attention to the recent distribution of the pamphlet containing the addresses delivered at the First Joint Meeting of the Scientific Alliance of New York, held at the American Museum of Natural History, on November 15, 1892.

SECTION OF ASTRONOMY AND PHYSICS.

The Section was called to order at 8:20 P. M., Professor REES in the chair.

A paper was read by Mr. C. A. POST on "A New Driving Clock for Equatorials." The apparatus described has been in successful operation for more than a year. It involves a new method of control (not electric), and a new differential slow motion for photographing. This slow motion can be applied in in either direction without stopping the clock, or changing its rate.

Mr. JACOBY communicated the results of some measures made by him upon Mr. RUTHERFURD'S plates of β Cygni. These additional measures seem to confirm the existence of a large parallax for this star.

Professor REES exhibited a photograph of a meteor trail, recently obtained by Mr. JOHN E. LEWIS, of Ansonia, Conn.

March 13, 1893.

STATED MEETING.

MR. CHARLES F. COX in the chair, and 72 persons present.

The minutes of the meeting of February 23, 1893, were read and approved.

The following papers were read by title and referred to the Publication Committee:

"The Myriopoda collected by the United States Eclipse Exploring Expedition to West Africa in 1889 and 1890," by O. F. Cook and T. S. Collins.

"Studies on the Life-History of some Bombycine Moths, with Notes on the Setæ and Spines of certain Species," by Alphæus S. Packard.

BIOLOGICAL SECTION.

Professor G. S. HUNTINGTON, in a paper on "Anomalies of Pectoralis, major and minor," referred to the value of those as often presenting reversions. He emphasized the evolutionary tendency in man to proximalization of the points of attachment of the shoulder muscle group, referred to cleavage variations in the anterior portion of brachio-sphalic sheet, and compared these with ontogenetic characters in anthropoids. Human anomalies in this group are best interpreted by cynocephaloids, and not by the higher forms.

The paper was referred to the Publication Committee.

Professor E. B. Wilson, "On Regeneration and the Mosaic Theory of Development," presented a brief critique of the latest results of Roux and Weismann.

The following paper was read, illustrated by specimens and maps:

THE SUNAPEE SAIBLING: A FOURTH NEW ENGLAND VARIETY OF SALVELINUS.

BY JOHN D. QUACKENBOS.

The sudden and unaccountable appearance, in large numbers, of a valuable food and game fish in any of our inland waters, would be hailed as a most important event, both in the angling and the ichthyological world. Assume that fish to be a prolific and rapidly growing salmonid, surpassing all congeners in symmetry and brilliancy of coloration, equalling the most delicate in table merits, and excelled in game qualities by the land-locked salmon alone—and you may readily comprehend the enthusiasm which, some seven or eight years ago, greeted the discovery of a New Hampshire charr characterized by such a synthesis of traits.

Until the year 1885, but three species of trout, or more properly charr (a Gælic word, meaning red or blood-colored), were recognized as native to New England, viz.:

I. The *Salvelinus fontinalis*, or common brook trout.

II. The *Salvelinus namaycush*, the longe, togue, lake, or Mackinaw trout.

III. The *Salvelinus stagnalis* of Jordan; *oquassa* of Girard and Günther, the diminutive blue-back of the Rangeley Lakes of Western Maine—the last, closely allied to species widely spead through Arctic America, as well as to the European saibling.

From this classification is omitted the *Salmo Agassizii* of Lake Monadnock, N. H., now recognized as a variety of brook trout, and the *Salmo hucho*, or hunchen trout, mentioned by Dr. Smith in his "Natural History of the Fishes of Massachusetts," 1833, and therein claimed to be related to the true *Hucho* of the Danube. Its forked tail, dusky hue, and reddish spots, coupled with the statement that it was brought to market in a frozen condition from lakes in New Hampshire and Maine, make it probable that the Massachusetts hucho was merely a variety of *namaycush*.

Even Professor Jordan, in an article on the Salmon Family, published in "Science Sketches," as late as 1888, is silent as regards a fourth New England species; although Professor Garman, of the Museum of Comparative Zoology at Cambridge, in his paper on the American Salmon and Trout (1885), calls attention, under the head of *Salmo fontinalis* to a form, Fig. 16, of which he says: "A knowledge of the younger stages of this fish from the same locality may lead to a separation of the form." Subsequent research *has* led to such a separation, and ichthyologists now admit the presence of a fourth variety of *Salvelinus* in New England—the *Alpinus Aureolus*, a golden-hued Alpine charr, whose life history and general characteristics it is the purpose of this paper to present.

As far as is known, the first specimens of this new fish to be distinguished from the well-known forms were taken in Sunapee Lake, Merrimac County, New Hampshire, during the summer of 1881, by Lieut. Ransom F. Sargent and Alonzo J. Cheney, respectively of New London and Wilmot—experienced anglers who immediately recognized in the three individuals captured by them specimens of a salmonoid distinct from the namaycush and from the brook trout of the region. The fish taken weighed from two to three pounds each, and were known by the name of "St. John's River trout," because they were believed to be descendants of fry planted in the lake in 1867, by the first Fish Commissioners of the State and supposed by the resident population to have come from the St. John River, N. B. The conspicuous development of the under jaw in the males led to the local names of "Hawk bill" and "Hook bill"; the silvery sides of the fish in summer gave rise to that of "white trout." In the two following years, 1882 and 1883, a sufficient number of the deep-swimming stranger was taken to excite comment and conjecture on the part of outsiders who had heard of its presence in Sunapee Lake; and in 1884, Colonel Elliott B. Hodge, of Plymouth, the New Hampshire Fish and Game Commissioner, finding confirmation in the reports that reached him for a view he seems long to have privately held, ventured the opinion that many Canadian and Northern New England lakes contained a large charr, whose habit of retiring to the deepest and coldest waters throughout the summer and of approaching the surface for a few days only at the end of October explained a general ignorance concerning its very existence. Colonel Hodge's theory received apparent substantiation from his accidental discovery in October, 1885, of vast numbers of a mysterious charr spawning on a midlake rocky shoal at Sunapee. He wrote at the time :

"I can show you an acre of these trout, hundreds of which will weigh from 3 to 8 pounds each. I could never have believed such a sight possible in New Hampshire. The new fish differs from the brook trout in many ways. The females have a brownish back and lemon-colored sides ; the males, a bluish-black back and golden orange sides. The fins are much larger than in the brook trout, and there is an entire absence of the mottling characteristic of the latter fish."

Thus Colonel Hodge recognized in this graceful high-colored charr, a new variety, and he lost no time in inviting the attention of scientists to the New Hampshire beauty.

Specimens were forwarded to the Museum of Comparative Zoology at Cambridge, Mass., and to Dr. Tarlton H. Bean, Curator of the Department of Fishes, National Museum, only to pronounced at both centres varieties of brook trout. Colonel Hodge resented this classification, and sent Dr. Bean other large specimens of the new fish, together with several Sunapee brook trout, urging a more minute examination. Dr. Bean compared the two forms with special care, changed his opinion, frankly admitted that Colonel Hodge was right, and pronounced the Sunapee trout "a Salvelinus of the Oquassa type, but of so enormous a size that at first he did not suspect its relation to that species."

The late Professor Baird inclined to the opinion that it might be a representative of a highly variable Arctic charr found in the Dominion of Canada and Greenland, viz.: The *Salvelinus Alpinus Arcturus.*

A controversy at once arose regarding the origin of this unique trout. Whatever its species, it was a new comer in the opinion of some ; in that of others, a native, the oldest of our charrs, representing the ancestral type and now almost extinct. Those who took the first view were chiefly residents of the immediate region. Such unhesitatingly declared that they had never met with the new fish prior to 1883 or 1884. They regarded the Oquassa (or "Quasky," as it began to be called) either as a descendant of some of the Salmonoidœ introduced into Sunapee in 1867 and succeeding years by the Fish Commissioners, or as a cross between one of these forms and the native brook trout. In no other way could they account for its sudden appearance in large and steadily increasing numbers.

A theory of descent from blue-backs imported from Maine in 1879 by Commissioners Webber and Powers as a food supply for the larger Salmonida, was soon set aside on the ground that the little trout of the Rangeleys rarely exceeds one-quarter pound in weight, and could not possibly, even if supplied with an abundance of appropriate food and exposed to the tonic effects of a favorable change of waters, ever attain the aldermanic proportions of the Sunapee charr. Moreover, Dr. Bean, in a scholarly paper, published in the *American Angler* and the *Forest and Stream*, February, 1888, called attention to six essential points of difference between the Sunapee trout and the blue-back, thus effectually disposing of the argument.

The theory of natural hybridism found few supporters among ichthyologists, and no introduction of charr other than the Rangeley *Salvelinus fontinalis* and *Salvelinus Oquassa* could be proved, as none had been officially reported. From the first, Colonel Hodge, believing in the existence of a similar charr in the Province of Quebec, championed the theory of aboriginality, ingeniously combating every objection made to it :—

I. That so conspicuous a food-fish could not for one hundred years have escaped the notice of anglers, poachers, and scientists alike, by showing how the habits of the white trout protected it from observation and persecution, it being rarely seen except late in October on mid-lake reefs, that is, at a time of year when angling was out of season, and in localities dangerous or impossible of access in the old-style unseaworthy flat-bottoms during the autumnal wind storms. The secluded habits of the European charrs explain in like manner the obscurity which has so long involved the life history of those fishes. Colonel Hodge further claims that ordinary fishermen knew no difference between the white and the brook trout, a thing not to be wondered at when such authorities as Garman and Bean failed at first to separate the forms.

II. The more serious objection that no cause can be shown why the white trout, if a native, should suddenly increase in the lake, so as to attract the attention of hundreds of observers, and be taken literally by the ton, Commissioner Hodge meets with the following clever theory : Before the introduction of black bass, about twenty-five years ago, yellow perch swarmed in the lake, and there being then no smelt food, subsisted largely on the eggs and fry of the lake-spawning charr. At the spring hatching-time these perch held carnival among the helpless alévins, almost effecting, by their periodic ravages, the extermination of the white trout. But as the black bass increased in number, they fell upon the perch in turn, until the lake was virtually rid of this voracious pest. Thus the trout, which had been reduced to the verge of annihilation, had a chance to increase. The black bass did not interfere with it for two reasons :

I. Both bass and trout have an abundance of easily caught and tasteful food in the land-locked smelts, which have multiplied since their introduction until now they literally school in millions.

II. Bass and trout are not found in the same sections of water at the same time, the trout keeping in a temperature of 42° to 45° (on the surface in May, 60 feet below in July and August); the bass preferring 65° to 70° in summer, and hibernating in winter and during the spring hatching time of trout. Thus freed from persecution, the saibling has increased, until it is now present in myriads. This is the most ingenious of all the explanations that have been advanced. It is based on facts throughout, and is difficult of overthrow, especially when coupled with a theory of the writer's, that after the introduction of smelts, about twenty years ago, the saibling, if native, learned so far to change their habits as to rise from the depths and follow this food fish to the shores during May and June, thus increasing the chances of discovery. Wherever the smelt schools, there the saibling will be found. An axiom of the Sunapee fisherman is : "Hold the smelts and you will hold the trout," so the smelts are baited in certain localities during the fishing season.

This theory of Colonel Hodge encounters but a single objection, viz.: If the perch and saibling have been fellows in the Sunapee basin since its excavation during the Glacial Epoch, why was not the process of extermination completed centuries ago?

It must have been in the case of other lakes on the same primeval water-shed, unless we are prepared to admit that an anadromous fish became land-locked in one inland lake alone, while avoiding other bodies of water much more accessible and equally compatible. Geology proves that Sunapee once discharged its waters through Newbury summit, and thus was tributary to the Merrimac. Hence it is fair to assume that when these trout migrated, following like man and the larger mammalia, but through watery channels, the retreating ice-fields and glaciers, they swarmed into many lake-basins, where they became extinct before the advent of the white man. Were perch the instruments of extermination? If so, why did they not put in as thorough work at Sunapee?

It is but right to state at this point that the history of the charr in some European lakes is the history of a fish that has disappeared within the memory of man. This is notably the case at Loch Leven, once the home of a charr that rivalled the magnificent fish of Windermere. The trout (*fario*) seems the fitter to survive.

While the discussion just outlined was progressing, charr identical with the Sunapee Lake form were sent from Dan Hole Pond, Carroll County, New Hampshire, and from Flood's Pond in the town of Otis, sixteen miles from Ellsworth, Maine, to Professor Garman and Dr. Bean. The water of both these lakes is deep, clear and cold, as in the case of Sunapee. Dan Hole Pond, at the head waters of the Ossipee River, is tributary to the Saco. Flood's Pond connects with the Union River, which enters Blue Hill Bay near Mt. Desert. Thus the new *Salvelinus* is represented in three distinct drainage basins in New England.

In company with Colonel Hodge I visited Dan Hole Pond in the summer of 1889, but failed to secure a specimen of the saibling. In the fall of 1890, however, several specimens were sent from the pond to Cambridge and to Washington, where they were pronounced identical with the Sunapee form. Old residents declared them identical, also, with trout which had for fifty years been speared on the same spawning bed. The present representative from Ossipee informs me, through Commissioner Hodge, that he has seen many individuals of this species weighing 10 and 12 pounds—all this, years, before a German saibling egg was imported.

I am indebted to Dr. Walter M. Haines, of Ellsworth, Maine, for the following facts regarding Flood's Pond: The Pond is three miles long by three-fourths of a mile wide. It is surrounded by high, well wooded land, and is one hundred feet deep, the bottom being pure white sand or gravel. There are the usual inlets and spring-holes. The outlet is a stream of considerable size, and has been dammed in many places for the last forty years. The Flood's Pond saibling, declared by Professor Garman to correspond exactly with the Sunapee fish, is known in the neighborhood as the "silver" or "white trout," to distinguish it from "the square-tail" or brook trout, and "the togue" or lake trout. It attains a weight of five or six pounds. Two hundred pounds have been taken by a single angler in a day, but it is never caught except in one particular locality. It spawns in the lake on a fine gravel beach, in three feet of water, and does not enter the inlets. Nothing but smelts are ever found in its stomach. Flood's Pond contains neither perch nor bass.

Since, then, by reason of dams on the outlets, no fishes of marine ancestry could, within the last fifty years, have gained access either to Dan Hole or Flood's Pond without artificial help, since land-locked salmon only have been planted in these ponds, and that quite recently; and since there seems to be trustworthy evidence of the existence of this so-called silver trout in each body of water for at least half a century, it is fair to conclude that the Salvelinus Alpinus Aureolus is a native of two Maine drainage basins, and, therefore, is aboriginal to New England, an American representative of the European saibling, red charr, or ombre chevalier.

But this does not prove its aboriginality to Sunapee Lake, New Hampshire, although, all circumstances considered, it renders such aboriginality highly probable, inasmuch as no data exist to establish a plant of this variety at any time in Sunapee Lake, and no German saibling eggs were brought to New Hampshire before January, 1881. The fact that the fry from the eggs sent to Plymouth in that year were placed in Newfound Lake, a body of water apparently in every way adapted to the nature of the saibling, but have never been heard from, is further significant here. It may prove that the foreign fish cannot find the necessary conditions in the New Hampshire lakes. The failure of the farmers at Sunapee to distinguish between the large brook trout and the saibling (if the latter fish was a native) is in contrast with the positive knowledge of a difference at Dan Hole and Flood's Ponds. Its explanation may be sought in the habits of the Sunapee saibling as already described; or in the ignorance of the few who in old times may ever have seen it, and who cared for nothing beyond the fact that it was good to eat.

Ford's Pond in Warren, and Silver Lake in Madison, New Hampshire, are associated with traditions of the fall spearing on their spawning beds of large high-colored trout, which are believed, from reports as to their habits and appearance, to have belonged to this same species. These two ponds, then, may represent a traditional habitat. The waters of Silver Lake find their way into the Saco; I was unable to learn whether Ford's Pond discharges into the Connecticut, or through Baker's River into the Merrimac.

I am under obligations to Dr. Bashford Dean, of the Department of Biology, Columbia College, for material assistance in determining the following anatomical description of the Sunapee saibling :—

Two specimens of 1 pound and 3 pounds respectively, were carefully examined.

FIN RAY FORMULA.

	In 1 lb. specimen.	In 3 lb. specimen.
Pectoral	14	13
Dorsal	13	14
Ventral	11	10
Anal	13	13
Caudal	26	28 (including rudimentaries.)

SQUAMATION.

1 lb. specimen.	3 lb. specimen.
Lateral 211 to 212	226
38 to lateral line	41
62 to vent	63

DENTITION.

(feebly developed as in the Irish charrs)

	1 lb. specimen.	3 lb. specimen.
Maxillary (superior and inf.)	13 and 14	16
Pre or Intermaxillary	4 and 5	4 and 3
Vomerine (very small)	6 in number	2 and larger
Palatines (right and left)	12 and 13	13 and 13
Glossal.	two rows of 4	5 and 4

GILL RAKERS.

(slender and longer than in the brook trout.)

18 in first row
18 in second row

PYLORIC CŒCA.

1 lb. specimen.	3 lb. specimen.
45 (small and short)	52

BRANCHIOSTEGALS.

9 on each side.

In young specimens, the gill-cover overlaps the root of the pectoral; not in adults. There are spots on the dorsal fin, and attention should be called to a post-ventral dermal appendage.

Such differences in individuals from the same locality would seem to impair the value of anatomical peculiarities as diagnostic marks. In fact, in a most able paper on the Saiblings, published in the *American Angler*, February 5, 1891, Professor Garman states that in foreign specimens examined by him the dentition differs, corresponding more or less nearly with that of the New Hampshire fish—that differences of age imply radical differences in teeth, fins, stomach, and especially gill-rakers—which latter, Professor Garman believes to be "most important in function early in life and to deteriorate with change to coarser food." The deterioration consists in a distortion not alike in any two individuals; "the rakers curve and twist in every direction like a lot of writhing worms suddenly become rigid." In old specimens, they lose their points and grow club-shaped. As to the number of gill-rakers, in saibling where Dr. Bean found 10 and Professor Jordan 14 to 15, Professor Garman counted 14 to 18. And in the New Hampshire charr, where the first found 14 and the second 11 to 12, Professor Garman counted 13 to 16. In our specimens, 18 were counted in each row.

The external characteristics of the Sunapee fish, however, distinguish it conspicuously from the three other charrs of New England. Its graceful build, small and delicately shaped head, small mouth, excessively developed fins, more or less markedly emarginate caudal, spots without the blue areola, and unmottled back, at once separate it from the brook trout and link it as closely as its structural peculiarities with Austrian, British, and Swiss congeners. The nuptial coloration is gorgeous beyond example among our indigenous Salmonidæ. Throughout the spring and summer the back is dark sea-green, blending on the sides into a flashing silver, which in turn deepens below into a rich cream. But as the October pairing-time approaches, the fish is metamorphosed into a creature of indescribable brilliancy. The deep purplish blue of the back and shoulders now seems to dissolve into a dreamy sheen of amethyst, through which the inconspicuous pale lemon spots of midsummer flame out in points of yellow or vermilion fire; while below the lateral line, all is dazzling orange. The fins catch the hue of the adjacent parts, and pectoral, ventral, anal, and lower lobe of caudal, are ribboned with a broad white margin. As in the case of the Windermere charr, these white margins of the fins are very conspicuous in specimens seen swimming in the water. There are great differences in intensity of general coloration, and the females are not usually as gaudily tinted as the males. The intermediate types and different depths of hue observable in an autumn school recall the public promenade in a West Indian city where all shades of transition are found from pure white to tawny black. Those who have seen the flashing hordes on the spawning beds, in all their glory of color and majesty of action, pronounce it a spectacle never to be forgotten.

Sunapee saibling kept in confinement entirely lose the sexual instinct, and with it the wedding garment. So sensitive are the females that their removal from the spawning beds to the State Hatchery on the opposite shore of the lake, only one mile distant, seriously interferes with the maturing process, so that it is impossible to secure eggs, the fish having frequently to be returned to the water several times during the operation. Hence, as far as possible, ripe specimens are selected on the natural spawning beds, and there stripped rapidly and returned to the lake. Instances are not exceptional in which females refuse to part with their eggs and carry them over to the next season. This tallies with Cholmondeley-Pennell's suggestion that some of the Windermere charr spawn in alternate years.

Although a vigorous fighter, the white trout is very easily injured, the prick of the hook often being followed by fatal consequences, especially in young specimens. Hundreds are thus unavoidably killed every summer. In this respect the Sunapee charr is very unlike the blue-back of Maine, of which Commissioner Stanley said:

"They are a hardy fish and nearly as tenacious of life as the eel or bull-head. I have frequently seen them alive in the morning after lying all night on the shore."

One other phase of Aureolus life is a marked tendency to deformity. Remarkable differences in shape, as well as coloration, are normal to the quadroons and octoroons of the Sunapee spawning beds; but these differences are sometimes carried to the verge of distortion or even monstrosity. Humped backs are not infrequent; but the most repulsive, and at the same time most common malformation is the shrinking of the mature fish into an eel-like shape, with abdominal respiration and an intensely reproachful human look in the cavernous eyes which fix your gaze with a mysterious intelligence. The death scene of such a fish will haunt one for days, tempting him to speculation in the field of metempsychosis.

Professor Garman has proclaimed his belief in the identity of the Sunapee, Dan Hole, and Flood's Pond *charrs* with the European saibling, and that "the affinities of these forms are closer to that saibling by way of an Atlantic steamer than by way of Greenland and Iceland."

Professor Jordan has said "the American charr is probably not a distinct species, but native to the waters where it is now found, and not an importation from Europe." "Should it appear," he continues, "that the saibling in that part of Germany from which specimens have been brought to America, have gill-rakers like those of the Sunapee trout, this opinion would be reconsidered." Professor Garman has disposed of the gill-rake argument, but, as far as I know, Professor Jordan has not further expressed himself in regard to the Sunapee form ; although in a recent article on the salmon and trout of the Pacific coast he states, that in the lakes of Greenland and the Eastern part of British America the European charr is as abundant as it is in Europe—a fact which has only lately been made manifest." Mr. J. G. A. Creighton, of Ottawa, Canada, writes under date of Feb 16, 1893 : "From the height and character of Sunapee Lake, it is not at all improbable that an Arctic variety may have survived there, which has perished, or been transformed, elsewhere south of 55° or 60° N. Lat. Arctic species must have been common to all our waters in the Glacial Period." Professor Garman writes me, of November 17, 1892, that "no good evidence has been advanced of the existence of this species on this continent, previous to 1884." It is a matter of record, however, that 60,000 German saibling eggs, the gift of the Deutsche Fischerei-Verein, were sent to New Hampshire in January, 1881. It is further to be taken into consideration that the writer of this paper had in his possession, at Sunapee Lake, in the summer of 1882, a four-pound specimen of the saibling in question—which could not have developed from fry hatched the preceding year! No saibling have ever been sent to Maine by the United States Fish Commission ; and, as has been shown, it is impossible that the fish in Flood's Pond can be descendants of the New Hampshire charr. The theory that there was nothing in recent years to prevent the *Salvelinus alpinus* of Sunapee Lake from descending the Connecticut River to Long Island Sound, and thence making its way into streams and connecting lakes from the shores of Connecticut to those of Greenland, may be disposed of in a single word—DAMS.

The Sunapee charr is undoubtedly a representative of the European form ; but reasons have been given why it is believed to be a native of this continent. It differs no more extensively from the several European varieties than they do among themselves. Von dem Borne, Professors Benecke and Dalmer, Wittmack, of Berlin, all speak of important differences in form, size and color, according to age, sex, season and habitat. All authorities allude to the solid sea-green or dark-blue of the back, the yellowish sides, and the red or orange belly. Benecke and Dalmar refer picturesquely to the half-moon tail. As to spots, there is endless variety. Some forms have none; some, large spots; others, small—yellow, orange and red—and singularly, in certain species, each spot is surrounded by a white ring or halo. The fins take their color from the back and sides, and have the broad white band. The foreign saibling is gregarious like the Sunapee form; lives similarly on crustaceans, worms and fish-food, and seeks the deepest and coldest waters.

The greater the altitude, the more intense the coloration and the smaller the fish. In Lake Zug, the saibling run eight or nine to the pound; in Lake Geneva, they are said to attain a weight of over twenty pounds. The flesh is white or red, which, however, makes no difference in the flavor. The foreign saibling is taken in nets, or with hook and line; it is eaten fresh or smoked.

Colonel Hodge has attempted to prove a dissimilarity between the German saibling and the Sunapee charr by crossing each with our common brook trout, and noticing differences in the markings of the resulting fry. He writes me that the eggs of the cross between the German saibling and our brook trout are larger than those of the cross between the Sunapee Aureolus and the brook trout, and that there are conspicuous differences in the fry of the two hybrids, both of which are fertile. Crossing our brook trout, with other forms of the foreign saibling, would certainly give different results again; so the experiments of Colonel Hodge cannot be regarded as conclusive, beyond establishing the fact *that the Aureolus of Sunapee is in no way connected with the particular form of German saibling sent to New Hampshire in* 1881; but this is a most important fact in the induction of its aboriginality to New England. Colonel Hodge further states another supposed difference: "The aureolus does not seek the streams to spawn; the saibling does." But the saibling does not always spawn in streams; the rule is the other way.

At Windermere, the charr spawn both on the rocky bed of the Brathay, and in the lake. Schroeder, in his "Katechismus der Kunstlichen Fischzucht," expressly states that the saibling in October and November ascends from the depths in which it usually lives, and spawns off sandy shores in the lakes. Professors Benecke and Dalmer describe great schools of fish spawning in October or later, even as late as January and March, on sand or gravel near the shores. The Sunapee fish, then, simply follows the practice of its European relatives.

Finally, there can be no doubt as to the economic value of this new fish. It is one of the most prolific of our salmonids, the female averaging 1,200 eggs to the pound, or 200 more than the brook trout. It is also a singularly rapid grower where smelt food abounds. The extreme weight known to have been attained in Sunapee is about eight pounds, although accounts exist of much larger fish in this water, and of specimens from Dan Hole and Flood's Ponds, weighing from fifteen to twenty pounds.

The Sunapee saibling takes live bait readily, and affords the angler superb sport if the tackle be light. With a seven-ounce rod and 200 feet of line, the killing of a five-pounder from a sail-boat, running across the wind, implies a delightful excitement that, to be appreciated, must be experienced. Three tons of this fish have been taken with hook and line in a single season, at Sunapee. The flesh is of a light salmon color, and when in its perfection excels in delicacy that of all other Salmonidæ.

We most confidently recommend this charr to the attention of State Commissioners interested in placing a valuable and easily propagated food-fish within reach of the people. It is *facile princeps*, from its rush at the cast smelt to the finish at the breakfast table. Those who best know it, most enthusiastically endorse, with a slight amendment, Professor Jordan's apothegm: "Nothing higher can be said of a salmonoid than that it is a (SUNAPEE) charr."

March 20, 1893.

STATED MEETING.

Mr. GARRETTSON in the chair, and about 110 persons present.

Commander THEO. F. JEWELL, U. S. N., delivered an illustrated lecture on "Torpedoes."

At the close of the address a vote of thanks was tendered the lecturer.

March 27, 1893.

STATED MEETING.

The meeting was held in the Law School of Columbia College, in conjunction with the Scientific Alliance of New York, in honor of the late Professor JOHN STRONG NEWBERRY.

Mr. CHAS. F. COX in the chair, and about 110 persons present.

Professor HERMANN L. FAIRCHILD, of Rochester University, delivered the following address:

A MEMOIR OF PROFESSOR JOHN STRONG NEWBERRY.

BY HERMANN LE ROY FAIRCHILD.

As the bright declining sun is suddenly eclipsed by clouds and so sinks slowly into night, so passed from earth our glorious friend. But in the memory and hearts of those who knew him he still lives, as a noble personality, impressive in appearance, charming in companionship, wise in counsel, himself greater than any work that he has done. To review his life will be both a profit and a delight. He was great enough to demand our reverence, good enough to claim our affection and human enough to win our sympathy. It is the highest tribute that those who knew him best loved him the best.

Dr. Newberry was, taking him all in all, a truly great man. To a remarkably fine intellectual and moral endowment there had been added an unusually wide experience and a large degree of scholarly attainment. His abilities were such that he could have taken a high place in almost any profession. In his chosen field of natural science he was a master, and everwhere, whether in society, the university or scientific circles, he was a conspicuous figure, admired and honored.

By gifts of birth Dr. Newberry was a naturalist, and his inborn inclination toward geologic science triumphed despite the fact of his early selection of another profession. He was born before the days of scientific schools, and lacked the advantages of special instruction and scientific association. In his scientific work he was largely a self-trained observer and an independent worker, one of the few great "naturalists" by impulse. His range was not limited nor his independence checked by undue regard for authority of predecessors or teachers. His relation to schools of science was creative, not receptive.

HIS LIFE—CHRONOLOGY.

Dr. Newberry's life was not particularly eventful or romantic. Its history is the story of an active leader in his chosen field, who did the work, assumed the responsibilities and enjoyed the honors that came to him.

Dr. Newberry was the youngest of nine children, seven daughters and two sons, none of whom are now living. He was born December 22, 1822, in the town of Windsor, Conn., where his eminent ancestors had lived since the settlement of the town by immigration from Dorchester, Mass., in 1635, nearly two centuries. His grandfather, General Roger Newberry, was one of the Directors of the Connecticut Land Company that in 1795 purchased of the State of Connecticut the bulk of the tract in Northern Ohio known as the "Western Reserve of Connecticut." Henry Newberry, the father of John Strong Newberry, removed to the Western Reserve in 1824. He owned at first a square mile of land near the present center of the city of Cleveland, but exchanged it for a tract at the falls of the Cuyahoga River, nine miles south, where at that time the water power was very valuable. He founded the town since known as Cuyahoga Falls, and engaged actively in the development of the coal resources of that region. Upon his property was mined the first coal known to have been offered for sale in Ohio.* Mr. Newberry built a fine house of a local red sandstone, erected mills and was very successful in his enterprises.

Dr. Newberry's early life was passed amid fortunate conditions of competence and refinement, and the influence of his natural surroundings on the mind of the boy can be plainly traced. We can be sure that while he roamed the fields and woods with boyish love of sport he had the observant eye of the naturalist. The deep rock gorge of the river gave him a geologic section and an illustration of geologic agencies, while the coal mine on the estate supplied the plant fossils that awakened an interest in paleontology, which was to become a passion and the subject of much of his life work. His perseverance is proof of his scientific bent, for by his own collecting and by exchange he accumulated a geologic cabinet which filled a large room in his father's house, and was the nucleus of what eventually became that extensive collection, now one of the glories of Columbia College. Before he entered college he had collected and studied mollusca and made an herbarium and a catalogue of the flora of the state, and had substantially mastered the zoology and botany of his county.

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* For most of the facts relating to the ancestry of Dr. Newberry the writer is indebted to Mrs. Newberry, and to his oldest living son, Arthur St. John Newberry, of Cleveland. For facts relating to his boyhood and college days to Rev. N. S. Burton, Needham, Mass., Rev. E. Bushnell, Cleveland, Ohio, and Hon. M. C. Read, Hudson, Ohio.

In 1846, at the age of twenty-four, young Newberry graduated from the Western Reserve College, at Hudson, Ohio, where, in the preparatory school, he had also made his preparation. During his college course and afterwards he was a close friend of his teacher in geology and natural science, Professor Samuel St. John. In college he was the same popular, kind and manly spirit that we knew in later life. A classmate writes of him: "Not a coarse word, not a cruel speech or act, not an ungentle thing of his doing occurs to the recollection of intimate acquaintance with him."*

Another classmate writes: "He was a thoroughly manly man, a most congenial companion, a faithful student, not ambitious to excel, though 'facile princeps' in his favorite studies, and above the average in all; with a choice fund of wit and humor which he never used to give pain, but always pleasure; a self-poised and 'all round man' not often met with at his age. Though he had enjoyed advantages for social culture superior to most of his classmates he showed no consciousness of superiority to any. His tastes were refined and pure, and I cannot conceive him capable of a mean or dishonorable action. I think he had a very just estimate of his own abilities. He certainly was not conceited, and was not self-distrustful."†

After graduation he studied medicine as a post-graduate of the college and was assistant to Samuel St. John, the Professor in Chemistry in the Cleveland Medical School, from which he took his degree of M.D. in 1848. During the year following he practiced medicine at Cuyahoga Falls, and married Miss Sarah B. Gaylord, of Cleveland. In the autumn of 1849 he went to Europe for further medical study. Besides his attendance upon lectures and clinics in Paris he frequented L'Ecole des Mines and Le Jardin des Plantes, and heard the lectures of Adolphe Brongniart, the great paleobotanist of that day. Before returning to America he visited the south of France, Italy and Switzerland.

In 1851 he resumed the practice of medicine in Cleveland, which he continued for about four years. During this time he kept up his interest in natural science and published ten papers, all in natural history except one, and the last four on fossil plants. His library and collections must even at this time have been well known, for during 1853 or 1854 they were used by Leo Lesquereux, who received from Dr. Newberry much help in the beginning of his labors on the plants of the Carboniferous.

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* From an article by Rev. E. Bushnell, in *The Adelbert*, January, 1893.

† From a letter to the writer by Rev. N. S. Burton.

Notwithstanding Dr. Newberry's flattering success as a physician his inclination toward scientific work was unconquerable, and it is evident from the following extract that his heart was not in his medical practice : "A conversation with him in his Cleveland office about two years after he opened it indicates his modesty and his high standard of attainment. He was asked, by me whether he intended to make the practice of medicine the work of his life. His answer was, 'no, I am prosecuting my studies with the hope that some day I may be able to fill a place like Professor St. John's.' "*

In 1855 he left his practice and accepted the position of geologist and botanist on the government expedition to northern California and Oregon, under Lieut. Williamson. The party left New York May 5, 1855, reached San Francisco May 30, and began field work, having reference to a route for the Pacific Railroad, near Benicia July 10th. Passing northward through the Sacramento Valley, and by the Klamath lakes, they reached the Columbia River October 9th, but detached parties were in the field until the middle of November. The party returned to Washington, D. C., late in January, 1856. Dr. Newberry made large collections in geology, botany and zoology and spent the following year in Washington preparing his report, which is contained in the sixth volume of the Pacific Railroad Reports.

In 1856–7 he was Professor of Chemistry and Natural History in the Columbian College, Washington, D. C.†

Dr. Newberry had scarcely completed his report of the Williamson expedition before he became the physician and naturalist of the Colorado Exploring Expedition under Lieut. Jos. C. Ives. In charge of one detachment he left San Francisco October 28, 1857, by coast steamer for San Diego and crossed the desert to Fort Yuma, where he awaited the main body of the party, which sailed from San Francisco four days later, and after much delay by adverse winds in the Gulf of California reached the mouth of the Colorado November 29, and there putting together a small iron steamboat, carried in sections from Philadelphia, arrived at Fort Yuma January 9, 1858. During this delay Dr. Newberry had employed his time in exploring the surrounding region and in making valuable scientific collections. The expedition steamed up the Colorado river as far as the mouth of the Black Canon, which was reached

* Extract from a letter to the writer by Hon. M. C. Read, of Hudson, Ohio.

† In some publications it is incorrectly stated that he held this position until 1866. He held it only one year as here stated.

March 5, where an accident ended the steamboat voyage. The exploration of the Canon was continued thirty miles farther, then the party returned to Mojave Valley and March 24 the steamboat "*Explorer*" was sent back to Fort Yuma. The party with escort left the river, explored the Colorado Plateau some distance, then struck eastward past the San Francisco Mountains, reached Fort Defiance May 22, and returned east via Santa Fé and Fort Leavenworth. Dr. Newberry ever after took great interest in the Moquis tribes with which he became acquainted upon this trip.

The report of the Ives Expedition was published in 1861. The geological report covers all the region which Dr. Newberry traversed from San Diego to Fort Leavenworth, and was the first detailed description of the lower Colorado region.*

The year following Dr. Newberry was again in the field as geologist of the San Juan Exploring Expedition, under Capt. J. N. Macomb. This expedition started from Santa Fé about the middle of July 1859, passed up the valley of the Rio Chama, across the continental divide to the head waters of the San Juan, thence into southwestern Colorado and southeastern Utah to near the junction of the Grand and Green rivers, and returned by a circuitous route to Santa Fé in November. On account of the demoralization caused by the war the report on the geology and paleontology was not published until 1876. It is important to note that it was then printed exactly as written sixteen years earlier. That it should have been published so long after the work was done and subsequent to other work in the region is proof of its value, and of Dr. Newberry's confidence in the accuracy of his own earlier work.

The outbreak of the war of the rebellion found Dr. Newberry in Washington, in the service of the War Department, with which he had been connected for five years as Assistant Surgeon. In the supreme hour of his country's peril he forsook his scientific work and gave to the nation the benefit of his medical training. On the 14th of June 1861, he became a member of the U. S. Sanitary Commission and immediately entered heartily into its work. On the first of September he resigned from the army and took the Secretaryship of the Western Department of the Sanitary Commission, having supervision of the work in the valley of the Mississippi, with headquarters first at Cleveland but afterwards at Louisville. By correspondence and visitation he "began the work of turning into one great channel the thousand springs of philanthropy and patriotism that were bursting out in ham-

*In 1853 Jules Marcou had traversed the region on the 35th parallel as geologist of one of the Pacific Railroad exploring expeditions.

let and city all over the land." Depots for the distribution of hospital supplies were rapidly established and plans made for the relief of sick and wounded. During all of the years of the war Dr. Newberry was active in ameliorating the sufferings of both friend and foe, which, with his kindness of heart, was doubtless a much more grateful work than would have been that of aggression and destruction. In overseeing the work of his organization he at times followed the armies and was present at the battle of Chattanooga.

The following extract from a letter by Hon. M. C. Read, one of his assistants in this work, would show that Dr. Newberry had organizing and executive ability and power of leadership. "All the agents for this work were selected by Dr. Newberry and assigned to their special duties. With an executive ability that is rarely equalled he seemed instinctively to put every man at the task he was best fitted for and to keep him up to his most efficient work. All reported to him at least every month, and oftener when emergencies demanded. All were treated with the utmost kindness and consideration, and all learned to love and honor him. No part of his life work is entitled to higher honor."

His report upon the work of his department exhibits the character and magnitude of his labors. Over $800,000 in money were expended in the benevolent work of the commission, and hospital stores were distributed to a value of $5,000,000.

Dr. Newberry published only three scientific papers during the five years of his service on the Sanitary Commission, but added to his geologic collections which had become very large. His scientific reputation was fully established and at the incorporation of the National Academy of Sciences in 1863 he was named by Congress as one of the fifty original members.

At the close of the war Dr. Newberry was employed at the Smithsonian Institution as collaborator and referee in matters relating to geology.

When the chair of Geology and Paleontology in the School of Mines, Columbia College, was established Dr. Newberry was called to the place and honorably filled it from September 1866 to the time of his death, a period of twenty-six years. During the last two years, however, he was unable to perform its duties.

His extensive private collection in geology and paleontology was purchased by Columbia College and was the beginning of the geological museum which under his affectionate care has become one of the best in America. It is especially rich in fossil fishes and fossil plants, the two groups of his particular interest, and in collections illustrating economic geology, necessitated by the character of the instruction.

Of the events during this last third of Dr. Newberry's life rich in labor and fame, only brief notice can be given.

In 1867 he was President of the American Association for the Advancement of Science, at the Burlington meeting, and gave the presidential address. In the same year he received from his Alma Mater the degree of LL. D.

In February 1868, Dr. Newberry became the President of the Lyceum of Natural History in the City of New York (after 1876 the New York Academy of Sciences) and remained the president of the society until the year of his death. His name was enrolled in most of the learned societies in America, and in many foreign societies.

When the Ohio State Geological Survey was established in 1869, Dr. Newberry, who had kept his home in Cleveland, was called by Governor Hayes to the directorship and for several years the work absorbed most of the energy and time that could be spared from his college duties. The results will be spoken of later in this paper. An error was made in postponing the publication of the economic work and the appropriations were suspended in 1874. There was no formal termination of Dr. Newberry's survey, but from about 1878 he felt that his work there was over, and that there had been injustice and ingratitude, which wounded his sensitive spirit and perhaps somewhat embittered the later years of his life.

At the Centennial Exposition, 1876, Dr. Newberry was one of the judges, and prepared the report upon building and ornamental stones. From 1880 to 1890 he was President of the Torrey Botanical Club. In 1884 he was appointed one of the paleontologists of the U. S. Geological Survey, with particular reference to his favorite lines of study, fossil plants and fossil fishes.

One of his highest and most appreciated honors fell to him in 1888 in the award of the Murchison Medal, conferred by the Geological Society of London for distinguished services to geologic science. In 1889 he was First Vice-President of the Geological Society of America, which he had helped to institute in 1888. He was one of the committee of the American Association for the Advancement of Science which was instrumental in organizing the International Congress of Geologists, and perhaps his crowning and well deserved honor as a geologist came in his election as President of the Congress for the Washington meeting, in August, 1891. But the tribute came too late for him to perform the duties of the office, or even to attend the meeting.

During the winter of 1889-90 Dr. Newberry was ill through exhaustion and a severe cold, from the effects of which he did not fully recover. The following summer vacation, which should have been wholly taken for recuperation, was used in close work upon the Amboy Clays flora. All his life his vacations had been periods of ardent scientific work and he could not realize the necessity of rest. On the 3rd of December, 1890, he was stricken with paralysis. For only a brief period in 1891 was he able to be in his rooms at the college for a few hours at a time. Restoration was sought in the South, in California, on the shore of Lake Superior and at his home of later years in New Haven, Conn., but the rest had been too long deferred. On the night of December 7, 1892, at his residence in New Haven, the honored scientist, the beloved teacher, the noble man went to his well-earned repose.

Dr. Newberry's oldest son died after beginning medical practice in Cleveland, but Mrs. Newberry with five sons and one daughter are now living to do honor to the memory of the revered husband and father.

SCIENTIFIC WORK.

Dr. Newberry was perhaps the broadest minded, the most cultured, the best equipped by natural gifts, education and experience, of American geologists. Indeed, he was too broad, and deeply interested in too many branches of natural science to attain the very highest position in any one. He was too great a naturalist to be a specialist. His love of all sides of nature would not permit him to concentrate his work upon a single department.

That Dr. Newberry's work covered a very wide range a glance at the list of his publications will show. In many branches of geology and paleontology he was conspicuous, and his work was recognized in allied sciences. The titles in the list of his papers and books may be classified as follows :

Geology, general . . .	73	
" economic . .	38	
		111
Paleontology, vegetable . .	43	
" animal . . .	25	
		68

Botany	7
Zoology	6
Physiography	6
Archæology	5
Biography	3
Miscellaneous	5
Total	211

IN GEOLOGY.--Two of the four earliest published articles by Dr. Newberry in 1851, were geological. But his first important publication in geology was in 1857, on the Geology of California and Oregon, in Vol. VI. of the Pacific Railroad Reports. This, with his botanical and zoological reports in the same volume, are the result of his first serious professionally geological work, as geologist and botanist to the Williamson Expedition. This, first of his formal reports, exhibits well the good qualities of his work, namely, an appreciation of the more important phenomena, keen insight into their relations, a remarkable power of generalization, with lucid presentation. Our admiration for this work is increased when we consider that these reports were prepared and published, with elegant plates, in the year following the expedition. They justly made his instant reputation and the trip was naturally but the introduction to his labors in the far West. His more elaborate geological report of the Ives Colorado Exploring Expedition was published in 1861, and that of the Macomb Expedition not until 1876, as already stated.

That Dr. Newberry was a pioneer in geologic exploration of the far west has not been sufficiently recognized by the younger generation of geologists and the public at large. His work was in advance of his time. The region was so unknown, the geological phenomena so stupendous, the problems so new, that even those capable of appreciating the results could not immediately use them. There was no popular interest, the field being unknown and inaccessible. But more than these was the fact that the interest of the whole nation was absorbed in the political questions of the hour, and the war of the rebellion prevented scientific work and exploration. Even Dr. Newberry yielded to the demand of the hour and gave himself to the service of his country. When the war was ended, Dr. Newberry's work was in the east. Other men went into the western fields, traversed the areas so well described by him, built upon his foundations, found an audience and public appreciation and received a reward not less their due that Dr. Newberry never wholly received his.

As a professor in Columbia College, Dr. Newberry received a handsome salary and found much time to devote to his chosen work outside of his college duties. During this period of twenty-four active years he was incessantly working, and always with more upon his hands than he could properly dispose of. He accomplished, however, by his industry, a vast amount of the best work of his life. All but thirty-six of his 210 published papers were written after 1866.

Between 1869 and 1882 he published the several reports of the Ohio Geological Survey, consisting of three brief reports of progress and seven volumes of final reports, four of these in geology, two in paleontology and one in zoology, and a geological atlas. He personally did a large part of the field work and wrote the descriptions of a number of the counties. In the course of his work about Lake Erie he arrived at important conclusions concerning the preglacial drainage of the glaciated region and of the geological history of the Great Lakes, which later investigations have justified and which show his powers of insight and generalization.

Early in his work, Dr. Newberry made practical application of his knowledge, his first paper in economic geology bearing date 1857. Thirty-eight of his titles fall into this class, most of them, however, after 1880. His opinion came to be highly valued and much sought after in relation to various kinds of mining properties, and frequent journeys were made in different directions, even to Mexico. Probably no other man has had, from personal observation, so full knowledge of the geology and resources of our national domain. The economic collections of the Columbia Museum were enlarged by these scientific trips to mining and quarrying districts. He also had a practical interest in the application of his science, and at one time was a large holder of petroleum lands, and had interests in Vermont marble quarries.

Dr. Newberry was one of the editors of Johnson's Cyclopedia, and wrote several of the papers in Appleton's Cyclopedia.

It is evident that Dr. Newberry's early experience in the western fields greatly influenced his mind and all his later work. To an intellect naturally comprehensive and sympathetic the years spent among the imposing natural features of the west added great breadth and power. The sweep of his experience, with his learning and mental grasp, enabled him to treat geological problems in a large way. He was never trivial or flippant or superficial. In his speaking and writing the loftiness of his theme was felt, for in describing so simple a thing as a fossil leaf, or shell, or fish-scale, he was reverent, as one dealing with the record of the earth's organic history. He made a scientific use of the imagination, and having in his mind, he reproduced to his audience, a picture of the geological conditions or phenomena he was describing.

IN PALEONTOLOGY—Dr. Newberry's most elaborate work, and on which his fame will more firmly rest, is that in paleontology. The study of coal-plants was one of his earliest pastimes, and during his medical course in Paris he improved his opportunities for enlarging his acquaintance with the science. If he had made a specialty of vegetable paleontology he could have become the foremost authority of his time. Forty-three titles of his papers belong to paleobotany, five of them dated as early as 1853. In 1884 he was made a paleontologist of the United States Geological Survey, and published, in 1888, Monograph XIV, on the "Fossil Fishes and Fossil Plants of the Triassic Rocks of New Jersey and the Connecticut Valley." Two unpublished monographs, "The Flora of the Amboy Clays" and "The Later Extinct Flora of North America," will appear as posthumous works under the editorship of his pupil and friend, Arthur Hollick.

Following is a critical estimate of Dr. Newberry's work in paleobotany by a present worker in that field :

"Dr. Newberry was a great geologist, without which qualification no one can appreciate the full significance of fossil plants. He never spoke of them without evincing a lively consciousness that they were once real and living plants, and that they belonged to the great record which time has made of the events which have transpired in the history of the earth. It was this constant realization of the objective truth which geology unfolds, a state of mind apparently wanting in the majority of geologists and paleontologists, that gave Dr. Newberry's utterances their chief weight, as well as their peculiar charm.

"Dr. Newberry was not a good botanist. He had once been, but had neglected to keep pace with the science. Moreover, he seemed to have very little interest in the more important principles of botany. He was utterly indifferent to questions of classification, and to judge from his published papers one order of arrangement was as good for him as another. This was not from lack of knowledge, except so far as indifference checked the effort to know, and he was not wholly indifferent to the order of development of plant life, as his article on Fossil Botany in Johnson's Cyclopedia shows, although at the time that was written the true order had not yet been established as it is understood to-day, and his admissions of the apparent failure of plants to sustain the general law of development might have then been justified.

"Of Dr. Newberry's early pioneer work on the Carboniferous flora of America, I do not profess to be a competent judge, but I believe it was as good as could have been done at that time. His determinations of the later forms have not all stood the test of time, but the same can be said of every worker in this field. He was no species-monger, and not prone to found species on insufficient material. His descriptions were all governed by strong common sense, and, unlike many other paleobotanists, he never forgot that he was dealing with real things. His discussions, therefore, of doubtful or unknown forms were always directed to ascertaining what they really were and not merely to deciding what they should be called.*

Dr. Newberry's first published paper, 1851, had reference to fossil fishes, and twenty-four publications, distributed through the years, prove his continuous interest in ichthyic paleontology. In the later years of his life this branch seemed to have the greatest fascination for him, and he never wearied of talking about the remains of the remarkable Devonian fishes which he had described in the Ohio reports and deposited in the Columbia Museum, As early as 1856 he began publishing descriptions of the paleozoic fishes of Ohio, and in Vol. I., Pt. II., and Vol. II., Pt. II., of the Ohio Survey Reports, he described the most remarkable of fossil fishes, the Dinichthys, which has probably attracted more attention from the scientific world than any other single description in his original work.

The reports upon the fossil fishes for the Illinois Geological Survey were made by Dr. Newberry and published in 1866 and 1870. In addition to Monograph XIV of the United States Geological Survey, on the "Fossil Fishes and Plants of the New Jersey and Connecticut Trias," above referred to, he published an elaborate work in 1889, Monograph XVI of the United States Geological Survey, on "The Paleozoic Fishes of North America."

Dr. Newberry kept himself informed as to the work done by others in ichthyic paleontology, and was very familiar with the older writers. His discoveries were numerous and important, and his detailed work was thorough and conscientious. He knew more about paleozoic and mesozoic fishes than any one else in this country. He gave little attention to the taxonomy

* Extracted from a letter to the writer by Prof. Lester F. Ward.

of his subject, and was, perhaps, somewhat indifferent to classification, and did not attempt to seriously philosophize.*

IN BOTANY.—His best work in botany, exclusive of paleobotany, was done in the earlier years of his work, before it was crowded to one side by geology. Before he entered college he had, as stated above, gathered an herbarium and had made a Catalogue of the Plants of Ohio. This list was published in 1859, making forty-one pages of the Ohio Agricultural Report of that year. His earliest and best botanical publication was the report in 1857 on "The Botany of Northern California and Oregon," in the sixth volume of the Pacific Railroad Reports. His chapter in this elegantly illustrated report upon the forest trees of the region described is a classic in American forestry.

IN ZOOLOGY.—Dr. Newberry was, as a boy, interested in the mollusca, and one of his earliest papers, 1851, was upon this group. Only five papers of his can be strictly classed as zoological, apart from the paleozoology, the most important being upon the zoology of Northern California and Oregon. However, there was no great branch of animal life with which he was not very familiar.

RELATION TO NEW YORK SOCIETIES.

Rarely in this country has one man been longer at the head of a prominent scientific society continuously and without opposition. For twenty-four years Dr. Newberry honored the New York Academy of Sciences as its President. He was first elected in February, 1868, and remained continuously in office until February, 1892, when, on account of illness and absence, he was made Honorary President. During all this time there was no opposition to him, but, on the contrary, he was often re-elected in the face of his positive declination. He was seldom absent from the chair, and was a graceful and dignified presiding officer. In later years, perhaps, he did not use the power of his position and reputation for the benefit of the Society to the extent that a critical judgment, or the expectation of members might have demanded, but he was ever more than loyal, and gave the Society an added dignity and standing. And if he did not discover and develop the latent talent of the membership, or in the meetings draw out the modest members in discussion, he largely compensated by his own freely given knowledge. It was rare that any subject was presented before the Society to

* The writer is indebted to Professor E. D. Cope for the substance of this estimate of Dr. Newberry's work on fossil fishes.

which the President could not add something of genuine interest and value. Frequently his summing up of the discussion would give the very substance of the whole matter, and usually he would give, in his lucid way, the true bearings and the relationship of the presented matter to other subjects. In no circumstance did the range of his knowledge appear to better advantage than in the weekly Academy meetings.

It was very rarely that he presented a paper in writing, it being his habit to extemporize. This habit of extemporizing in public speech, and hesitating for the right word, gave to his utterance a drawling tone, which, to strangers, was very marked and unpleasant, but it was forgotten when they came to appreciate the man and his matter.

Dr. Newberry was chiefly responsible for the removal of the Academy Library first to the American Museum of Natural History, and then to Columbia College, and also for changing the meeting-place from the Mott Memorial Hall to the Academy of Medicine, and later to Columbia College.

The Torrey Botanical Club, for the decade 1880 to 1890, had Dr. Newberry as its President. He was a member of the Century Club, and of the New York Yacht Club.

HIS INFLUENCE.

With his attractive personality, rich experience, vast knowledge, and his social, generous nature, Dr. Newberry, more than any other geologist of America, was a "Nestor" to the younger generation of workers in geology. Many had worked under his direction; in later years many young men had been his students in the School of Mines, and a host of men had profited by his assistance or fatherly advice.

His high rank in the scientific world and his convenient location in the metropolis naturally brought to his rooms many visitors. No geologist on the continent had a wider acquaintance among scientific men, or was so affectionately regarded as a friend and counsellor by the younger geologists. For the youngest and the humblest he always had a cheery, cordial greeting. He was never too busy to drop his work for a caller, who was always made to feel that he was more than welcome. There was an unaffected cordiality and cheeriness in his manner which won instant confidence. No young man ever left his presence without encouragement and stimulus. His greatest influence, unseen but gracious and enduring, was in the personal contact with students and friends, and the impress of his marked individuality upon the younger men.

His amiability seriously interfered with his scientific and literary work, for his time was much broken by friendly visits. He would never turn away a caller to another time, no matter how urgent the task upon which he might be engaged. In is hours and work he was not systematic, and important correspondence or undertakings were neglected or left unfinished for lack of the time that a man less sociable, more severe and systematic would have found.

Like many men of large experience and attainment he was inclined to monologue in conversation, but there was an entire absence of anything like boastfulness or self-laudation. He was the most modest of men, and it was exceedingly rare to hear from him anything about himself. He had a fund of anecdote, reminiscence and personalities about other people, which, related in his picturesque and pungent way, made others willing to listen.

His style of writing was somewhat ornate, perhaps better described as picturesque, but very lucid and elegant. His short articles in Johnson's Cyclopedia may be taken as examples of his literary style, being models of clear scientific statement with enough of animation to vivify them. With his broad knowledge, his instinct of the true relations of facts, his capacity for generalization, his imagination, and his charming literary style, he might have become a great popular writer in natural history if he had sought such fame. But he wrote almost nothing of a popular character ; an article on "The Geological History of New York Island and Harbor," in the *Popular Science Monthly*, October, 1878, is, perhaps, the only one of such a kind.

HIS CHARACTER AND DISPOSITION.

In temperament Dr. Newberry was cheerful and buoyant. He was fond of companionship, and there was an element of humor in his conversation, sometimes even a sort of dignified gaiety in his manner. But like many persons of lively disposition, coupled with a sensitive and delicate spirit, he had his periods of depression, and a trifling impatience of manner at times was not inconsistent with a very kind and affectionate nature. A slightly irascible temper of later years was probably due to his mode of life, and to some disappointments, and was really more in manner than in reality. A certain extravagant and picturesque way of speaking of other men might sometimes have caused misjudgment by a listener who did not know his real kindness of heart. Like most earnest workers and writers in descriptive natural science, he was jealous of priority and sensitive to criticism, but he never cherished any malice, and his disagreements with other men were not of a bitter and enduring nature. A personal interview would always disarm him. He was exceedingly affable and considerate of the feelings of others, in the truest sense a gentleman, and his really fine nature was best shown by the gentleness and considerateness with which he always treated those beneath him in position, and the very humblest in his employ. This sweetness of manner seems to have been a characteristic of the man from his youth.

Dr. Newberry was not a fighting scientist, nor a debater. His temper was too fine and sensitive to enjoy conflict with men. He keenly felt any injustice, but only in private was he likely to tell his feeling or speak his mind of opposition. He was not a politician, nor a schemer, and never sought to use men for his own purposes. He was pleased with praise and appreciated the honors which came to him in justly large measure. He had a proper amount of self-esteem, some personal vanity and much true dignity, and was naturally sensitive, generous and affectionate. He had a passion for music, and his violin was a sympathetic companion on his early expeditions. He also had an artistic sense, and many illustrations of scenery and fossils in his reports were drawn by himself.

Upon the exploring expeditions, from 1855 to 1860, Dr. Newberry was of necessity separated from his family. His labors on the Sanitary Commission, 1861 to 1865, also kept him away from his home, and subsequently for twenty years at Columbia College, with his family in Cleveland or abroad, he had rooms in the old college building, and lived an irregular and somewhat lonely life.

HIS FAME.

The ending of his life was inexpressibly sad. He was stricken down while vigorous in mind, and with youthful feeling and ambition, and when many years might well have been anticipated for work and enjoyment; in the midst of work which he loved and upon which he felt that much fame rested. For two years he was compelled to be the helpless witness of his own impotence. We may not know the mental agony of those long months when his body refused to obey his will, and he was conscious of his departing intellectual powers. Some of us saw him during those months, and our love and admiration were increased as we beheld the proud, sensitive spirit trying to be cheerful and brave and hopeful when there could be no hope. From the scientific and social circles he was suddenly removed, and the world was compelled to go on without him, while in his loneliness he awaited the inevitable.

What will be his fame as time goes on? Upon what will it mainly rest? In several lines of work he achieved distinction, even eminence. His most enduring fame will be that of a student and translator of the earth's organic history. Possibly in time his published work may be superseded by fuller and more thorough treatises. But if he did sacrifice the future reputation, that required specializing and limitation, it was for the sake of broader scholarship and greater personal influence. If he be less influential in the printed page of future science he was the more powerful as a formative force in the day he lived. If he be less known of men in the coming years, it was to be better known of men while living, and to carry into the eternity a richer life and a broader intellect. Can we doubt which is the better fame? Dr. Newberry will live in a silent but a nobler way than merely by printed pages, in the universe of intellectual and moral forces, wherein must ever be the impress of his life. And his best renown is in the hearts of the many, who as young men and beginners in scientific work, felt his sympathy, caught some of his enthusiasm, and were by him stimulated and invigorated for life's work.

Professor James F. Kemp presented the following letters :

NO. I.

Letter from A. St. J. Newberry regarding Dr. Newberry's ancestry :

CLEVELAND, March 14, 1893.

Prof. H. L. Fairchild.

DEAR SIR—My mother has forwarded me your letter of the 8th inst., requesting that I should give you information, so far as I can, concerning Prof. John Strong Newberry's family history in America.

I take pleasure in submitting the following statement of facts:

Thomas Newberry, of Devonshire, England, settled in Dorchester, Massachusetts, about 1630. He died there about January, 1636, and his widow and children removed to Windsor, Connecticut, about the same year. His son, Capt. Benjamin Newberry, was the first named of seven (7) proprietors to whom Windsor was patented in 1685. He commanded the Military of the Colony. He left two (2) sons, Thomas, who was the ancestor of the Detroit and Chicago Newberrys, and Benjamin, who was our ancestor. Capt. and Major Benjamin, 2d, seems to have succeeded to his father's position as chief of the military forces of the Colony. His son, Capt. Roger, married Elizabeth Wolcott, daughter of Roger Wolcott, Governor of Connecticut. Capt. Roger graduated at Yale College in 1726, was a Deputy to the General Court for eleven (11) sessions. In 1740 he commanded a company from Connecticut in the expedition against the Spanish Main, and was present at the repulse of Admiral Vernon at Carthagena in April, 1741. He died on the voyage home.

General Roger Newberry, son of Captain Roger, received his commission as Lieutenant of the Colonial forces in 1767. He was commissioned as Major in 1775, the commission being signed by Jonathan Trumbull, Governor, and George Willys, Secretary, of "His Majesty's Colony of Connecticut." In 1777 he received a commission as Colonel, signed also by Jonathan Trumbull, Governor, and George Willys, Secretary, "*of the State of Connecticut.*" In 1781 he was commissioned as Brigadier-General, and in 1783, after the peace, as Judge of Probate. He was one of the proprietors of the Connecticut Land Company, who purchased from the State of Connecticut the northern counties of Ohio known as the "Western Reserve."

Henry Newberry, son of General Roger, went to Ohio in 1824 to look after his father's landed interest. He located his land at the falls of the Cuyahoga River, and founded the town since known as Cuyahoga Falls. Upon his property was mined the first coal known to have been offered for sale in Ohio.

My father, John Strong Newberry, was the younger of his two (2) sons. Mr. Henry R. Stiles, of Hill View, Lake George, Warren County, New York, in his book the "History of Ancient Windsor," gives a quite full account of the Newberry family. A new edition of this work is now in press.

I trust the foregoing will be what you need.

Yours truly,

A. ST. J. NEWBERRY.

NO. II.

Letter from E. Bushnell, a college classmate, regarding Dr. Newberry's college days.

Cleveland, O., March 15, 1893.

Prof. H. L. Fairchild.

My dear Sir—I never heard Dr. Newberry speak much of his childhood and youth. The impressions made on my mind by what I did hear from himself and others, are something like the following:

He was born in Windsor, Conn., and his father was a man of means, who came to Cuyahoga Falls, Ohio, and owned some coal mines and stone quarries. The Doctor is recorded as having prepared for college at Hudson. He had been there before we entered college in 1842, in the Preparatory Department. As to this geological collection I am not geologist enough to describe it. His father's house was a large one, of sawed brown stone. In one wing was an office, containing surveying instruments and the like. Back of this was a room, perhaps 15 x 18 feet, and my recollection is that it was so full that it was difficult to get around in it. My recollection is that the collection consisted largely of slabs of slaty coal, on which were impressions of large fern leaves.

He was a good scholar. He was sometimes interrupted by the fact that he was only eight miles from home. But I should say he was in the highest third of his class. He was a good singer, and played some on the violin. He was a very genial companion.

His father's family was composed of parents, and one brother and three sisters, as I remember them. They were cultivated and very delightful people. His mother remains, in my recollection, as a saintly lady, always to be revered. Yours truly,

E. BUSHNELL,
Treasurer of Adelbert College.

NO. III.

Letter from Professor J. H. VAN AMRINGE, of the School of Mines, regarding DR. NEWBERRY'S early connection with Columbia College:

NEW YORK, March 27, 1893.

Professor J. F. Kemp.

MY DEAR SIR—My acquaintance with Dr. John S. Newberry began in 1866 on his entrance upon his duties as Professor of Geology and Palæontology in the School of Mines.

The School had been opened just two years before. Prior to its establishment there was scarcely any such thing as the science of mining adapted to American conditions. This school was intended to supply it. It was further designed as a step in the direction of a School of Science as part of the University system to be developed at Columbia. During the first two years much had been done in arranging and conducting courses in mining and metallurgy, and in beginning the solid foundations on which the institution was to be based. The presence in the faculty of a trained geologist was felt to be a constantly growing necessity, and most happily for the immediate need and future development of the school Dr. Newberry was secured. His accession was hailed with delight. Possessed of great physical endurance and untiring industry, with an intense and infectious enthusiasm; with a mind original, singularly active, and well stored; with a judgment trained by wide experience in travel an l observation, and in the management of men; accustomed to refined and exact scientific inquiry, he was a great acquisition to Columbia College, and could not but become, as he did, an important factor in its orderly expansion. He was always loyally devoted to the best interests of the school with which he connected himself. His influence was strongly felt in the enlargement and enrichment of its courses of study, in the formation and extension of its scope. His counsel was wise, and he had the confidence and the profound esteem of his colleagues. His pupils held him in most affectionate regard, and many of them he inspired with an enduring love of learning and research. In his large, unique and admirably arranged collections, he was incomparable. His especial field as a teacher was in the higher regions of his science, and with advanced students. He was rarely qualified by nature and accomplishment to be, as he was, a great university professor.

Very truly yours,

J. H. VAN AMRINGE.

NO. IV.

Letter from Professor EDWARD ORTON, the present State Geologist of Ohio, especially with reference to Dr. NEWBERRY'S connection with the earlier Ohio Survey:

COLUMBUS, O., February 17, 1893.

MY DEAR PROFESSOR KEMP—I am glad to join with the members of the New York Academy of Science in paying a tribute of affection and respect tō the memory of Dr. Newberry. I knew him well, and was closely associated with him for a number of years in a work which lay near his heart, viz.: the Geological Survey of Ohio.

A geological survey of Ohio was begun under favorable auspices in 1837, but it was brought to an abrupt termination in 1839, mainly because of the financial condition of the State at that time.

From this date forward, all the friends of the science in the State looked to a resumption of the work of the Survey, and many efforts to bring about such a result were made which proved fruitless. It was left to Dr. Newberry to draft a bill in 1869, which was passed by the Legislature, providing for a geological and natural history survey of the State. Governor Hayes appointed Dr. Newberry Chief of the Survey. In July of that year he entered upon the work. He brought to it the results of years of study in almost every section of the State, but particularly in the coal fields. He attacked the problems of correlation with enthusiasm and success. By the and of the season a good beginning had been made. The "Cliff Limestone" of the first survey had been resolved into its four components, and the Lower Helderberg limestone, which, up to this time, had never been identified in the State, was found to cover a far wider area than any other single element of the group. A geological map of the State was completed, and detailed examination of counties was in progress in all the districts into which the State was divided.

This was, perhaps, Dr. Newberry's happiest year in connection with the Ohio Survey. Before the end of 1870, a difference of view as to the prosecution of the work had developed within the organization of the Survey, and legislative inquiries followed such differences. In all these questions and controversies Dr. Newberry always carried his side when he was on the ground. If he had had only the work of the Survey on his hands, he could have had his own way with it, but as he sometimes reminded the Legislature, "the absent are always wrong."

In spite of such interruptions he followed out his original plans in their essential features. The two volumes of palæontology of the Survey were his special pride, and remain as honorable monuments of his scientific acumen and his learning. His treatment of the Devonian fishes of Ohio constitutes the opening chapter of one of the most remarkable revelations of palæontology.

My relations to Dr. Newberry during these years were most cordial and intimate. He was prompt and generous in his recognition of the good work of any subordinate. His criticisms were kindly but penetrating and helpful. I have never known a man whose conceptions were clearer and higher as to the value of the increase of knowledge, *per se*, irrespective of the obtrusion of personality into the questions involved. "The truths that we discover, the advances that we make," he would say, "are certain to remain, to become a part of the established knowledge of men, but the worker himself cannot long escape oblivion, at the best."

Dr. Newberry labored faithfully in his own field, and made splendid contributions to science. The *work*, we are sure, will remain as a permanent addition to knowledge; the memory of the *worker*, the genial friend, the inspiring companion, the broad-minded student of nature, we hereby pledge each other, to keep fresh and green during the hours that remain of our own little day.

I am, my dear Professor,

Faithfulty yours,

EDWARD ORTON.

NO. V.

Letter from SIR ARCHIBALD GEIKIE, Director General of the Geological Survey of Great Britain :

28 Jermyn Street, London, S. W.
16th February, 1893.

Dear Professor Kemp—I am glad to learn from your letter of the 5th inst. that it is proposed to hold a meeting in memory of Dr. J. S. Newberry, and I most sincerely wish that I could be present at it to add my little tribute of respect, admiration and affection. It has seldom been my lot to meet a man who at once so established himself in one's inner heart as a friend to be entirely trusted and loved; one whose sympathy went out to you in a hundred ways, and who at the same time commanded your deepest respect for his brilliant intellectual gifts, and for that strong will and brave spirit that carried him through all difficulties and opposition. I never knew a man whose true character was more vividly expressed by his face, and I shall cherish, as long as I live, the memory of that noble head with its eye like an eagle's, its firm set mouth, and that play of kindly humor that used to light up the whole expression of his countenance.

Of his scientific career, of the wide range of his activity, and of the value of the contributions with which he enriched science, I have no room to say anything here. I trust that among his surviving friends some will be found anxious to give the world a clear outline of the enormous amount of work which he achieved.

I dwell rather on his personal character, and on the loss which his death has brought on all who knew him. For myself, one of the strongest links which bound me to the States has now been severed, but amidst my sorrow I rejoice that it has been given to me to have the privilege of knowing and loving such a man. With truest sympathy in your efforts to do honor to his memory,

Yours ever truly,

ARCH. GEIKIE.

Mr. J. W. Holloway, of the Worthington Co. and President of the Engineers Club, followed with personal reminiscences of Dr. Newberry, drawn from the early days when they were boys together at Cuyahoga Falls. Remarks were also made by Prof. J. J. Stevenson, Prof. R. P. Whitfield, Prof. J. K. Rees, and Prof. D. S. Martin.

BIBLIOGRAPHY OF PROFESSOR J. S. NEWBERRY.

EDITED BY J. F. KEMP.

The original list on which the following bibliography is based, was prepared by Dr. Newberry himself in 1889. It contained, however, many gaps and omissions, which have been filled as well as possible. In this work much assistance has been rendered by Mr. ARTHUR HOLLICK, Dr. N. L. BRITTON, Professor L. F. WARD and Professor H. L. FAIRCHILD to whom grateful acknowledgments are due. Practically, the same list as this, is printed in chronological order in the *School of Mines Quarterly* for January, 1893, p. 99, and an extra leaf of additions, which are incorporated here, was distributed with the reprints. The *American Geologist* for 1893 will contain the complete, amended, chronological list. Dr. BRITTON also published in the Bulletin of the Torrey Botanical Club for March, 1893, pp. 95-98, a list of the botanical papers of Dr. NEWBERRY and on pp. 94-95, a list of the plants which have been named after him. In the following, the papers are chronologically arranged under the headings: Archæology; Biography; Botany; Geology, Economic; Geology, General; Miscellaneous; Palæontology, Animal; Palaeontology, Vegetable; Physiography; Zoology.

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ZOOLOGY.

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"On a Cranium of Walrus found at Long Branch, N. J."--Proc. N. Y. Lyc. Nat. Hist., Vol. I. (1870), p. 75.

"Geological Survey of Ohio."—Zoology and Botany, Vol. IV., 8vo. Preface (1882. (Contains no Botany.)

"Uneducated Reason in the *Cicada*."—School of Mines Quarterly, Vol. VII. (1886), p. 152.

Dr. Newberry was also one of the editors of Johnson's Encyclopædia, having charge of Geology and Palæontology. He wrote many articles on these subjects for its pages, in 1875 and the years immediately following.

Biographical sketches of Dr. Newberry have been published in all the current biographical dictionaries and cyclopædias. Portraits of him appear accompanying such sketches in "Men of Progress," 1870–71, p. 317, and "Contemporary Biography of New York," Vol. V., 1887, p. 255. The Popular Science Monthly, Vol. IX., p. 491 (1876), contains a sketch with portrait, and in Fairchild's History of the New York Academy of Sciences, there is an excellent artotype. Since his death memorials have already appeared with portraits in the Engineering and Mining

Journal, December 17, 1892, p. 581 ; the Scientific American, December 31, 1892, p. 423 ; the School of Mines Quarterly, January, 1893, p. 93, with two steel portraits, one taken in 1865 and one in 1887 ; the Bulletin of the Torrey Botanical Club, March, 1893, with an artotype ; and the Bulletin of the Geological Society of America, Proceedings of the Ottawa Meeting, December, 1892, also with an artotype. A memorial, by Professor J. J. Stevenson, is to appear in the American Geologist for July, 1893, with a revised chronological bibliography by J. F. KEMP.

April 3, 1893.

REGULAR BUSINESS MEETING.

President BOLTON in the chair, and twenty-seven persons present.

SECTION OF ASTRONOMY AND PHYSICS.

A paper was read by Professor WILLIAM HALLOCK entitled "Investigations of the Temperature of the Earth's Crust." This paper gave an account of temperature measures made at Wheeling, W. Va., in a dry well 4,500 feet deep. These measures, when plotted, showed a small but distinct variation from uniformity in the rate of increase of the earth's temperature. The results have been described in Proc. Am. Assn., Vol. XL., p. 257 ; and Am. Journ. Sci., March, 1892.

Mr. Tatlock then read a note on the place of λ Ursæ Minoris, calling attention to the bearing upon the subject of Dr. ELKIN's recent heliometric triangulation of close polar stars. The matter was further discussed by Professor SAFFORD and Mr. JACOBY.

Professor SAFFORD read a paper entitled, "The Construction of a Catalogue of Standard Polar Stars." The paper dealt with the various peculiar difficulties attending the observation of close polar stars, as well as the complexity and great length of the resulting computations. The author referred to his own work in this direction, and stated that he hoped to publish before long, a complete discussion of all existing observations of close polars.

April 10, 1893.

Stated Meeting.

President Bolton in the chair, and thirteen persons present. The President announced the death of M. Alphonse De Candolle, an Honorary Member of the Academy.

BIOLOGICAL SECTION.

Prof. H. F. Osborn, on "The Evolution of Teeth in Mammalia in Its Bearing Upon the Problem of Phylogeny," reviewed the recent researches and theories of Kükenthal, Röse and Tacker upon the formation and succession of the dental series in mammalia and pointed out that especially in marsupials, cetaceans and edentates (with other placentates), the existence of two series of teeth was now abundantly proven, as well as the fact that *homodont* forms were derived from early *heterodont.* He then showed that recent discoveries demonstrated that in marsupials, teeth of the second series might be interposed in the first series—to explain the typical dentition of such forms as *Didelphys.* This transposition enables a comparison of dentition of marsupials with that of Jurassic mammalia (= i. $\frac{4}{4}$, c. $\frac{1}{1}$, p. $\frac{4}{4}$, m. $\frac{8}{8}$). It was further noted that the triconodont type (as *Amphilestes*) was probably the hypothetical point of divergence of placental mammalia. As to the form of crowns the theory (Kükenthal—Röse) that complex mammalian types were made by concrescence of simple reptilian cusps, was upon the evidence of the Jurassic mammalia, shown untenable—as well as the converse theory that cetaceans have derived homodynamous forms by the splitting of the cusps of triconodont.

Dr. Bashford Dean, in "Contributions to the Anatomy of *Dinichthys*," correlated the parts of this Devon-Lower Carboniferous Arthrodiran with those of *Coccosteus.* Notes were made upon the (1) disposition and character of the lateral line organs, (2) pineal foramen, (3) nasal capsules, (4) dentary plates (homologics), (5) ginglymoid articulation of lateral shoulder plates, (6) character of 'shagreen,' (7) probable disposition of paired and unpaired fins.

Prof. N. L. BRITTON presented a ""Note on the Genus *Lechea.*" This genus of Cistineæ is entirely American, and from the investigations of Mr. Wm. H. LEGGETT and Dr. BRITTON appears to consist of about fourteen species.

April 17, 1893.

STATED MEETING.

President BOLTON in the chair, and about sixty persons present.

Prof. W. Le Conte STEVENS delivered the seventh lecture of the Public Lecture Course, 1892-1893 on "Naples and Its Surroundings," fully illustrated by lantern slides.

At the close of the address a vote of thanks was tendered the lecturer.

April 24, 1893.

STATED MEETING.

President BOLTON in the chair, and thirty-six persons present.

SECTION OF GEOLOGY AND MINERALOGY.

Prof. KEMP exhibited four-toed tracks in Triassic Sandstone from McDowell's Quarry, Upper Montclair, N. J.

Dr. A. A. JULIEN read a paper entitled "A Study of the New York Obelisk as a Decayed Boulder," illustrated by lantern slides.

The following papers were read by title, "On the Organs of Special Sense in the Coccosteids," by Dr. Bashford DEAN.

PLANT DISTRIBUTION AS A FACTOR IN THE INTERPRETATION OF GEOLOGICAL PHENOMENA, WITH SPECIAL REFERENCE TO LONG ISLAND AND VICINITY.

BY ARTHUR HOLLICK.

In "The Medical Repository," Vol. III., 2d Ed., pp. 325-335, and Vol. V., pp. 212-215, published in the years 1805 and 1802, respectively, Samuel L. Mitchill indulges in speculations concerning the mineralogy and geology of Long Island and its vicinity. From his articles I quote as follows :

> *Long, or Nassau Island.* This piece of land, which forms the east and south sides of the bay and harbour of New York, extends north-eastwardly about 120 miles, and terminates in a fork; the shorter extremity of which is called *Oyster-Pond* [Orient Point], and the longer, *Montauk-Point*. . . . A ridge of hills runs almost the entire length of it on the north side and completely divides its waters. . . . The face of the country, on the one side of this elevation, which may be called the *Spine of the Island*, is exceedingly different from that on the other. On the north side it is variegated, uneven, and very much diversified with hills and dales; while on the south, little else is discovered by the traveller than a flat surface, sloping very gradually away toward the ocean.

This will stand as a very excellent general description of Long Island topography as we recognize it to-day, but the speculations concerning its geology, which follow, reveal the curious conceptions of men of science at that time, and cause us to smile involuntarily. He says :

> From a survey of the fossils in these parts of the American coast, one becomes convinced that the principal share of them is granitical, *composed of the same sorts of materials as the highest Alps, Pyrennees, Caucasus, and the Andes, and, like them, destitute of metals and petrifactions.*
>
> The occurrence of *no* horizontal strata, and the frequency of vertical layers, led him further to suppose, *that these strata are not secondary collections of minerals, but are certainly in a state of primæval arrangement.* . . .
>
> What inference remains now to be drawn from this statement of facts, but that the fashionable opinion of considering these maritime parts of our country as flats, hove up from the deeps by the sea, or brought down from the heights by the rivers, stands unsupported by reason, and contradicted by experience.

Nevertheless, when he comes to his general conclusions these show a remarkably correct idea of cause and effect. Thus, he continues :

A more probable opinion is, that Long-Island, and the adjacent continent were, in former days, contiguous, or only separated by a small river, and that the strait which now divides them was formed by successive inroads of the sea, from the eastward and westward, in the course of ages. . . .

Between Long-Island and the continent there are several shoals, with rocks scattered over them, which are, apparently *sunken* or wasted islands. These remains of what was, probably, in former days, upland of as great height as the neighbouring islands, afford strong evidence of the leveling power of the waves. . . .

Manchonack, the *Isle of Wight,* or *Gardiner's-Island,* is an irregular body of land, lying obliquely between *Montock* and *Oyster-Pond* points. . . . Here too the earth is crumbling down, and yielding to the impulse of the waves : for, besides the wasting of other parts of the shore, a part of the island, which was formerly connected with a point or headland by a high beach, has, within a modern period, been separated by the tide. The separated portion is called *Ram-Island.* . . .

Plumb-Island. There can be no reasonable doubt that this detached piece of land was formerly connected with Long-Island at Oyster-Pond point, from which it is now distant about three-quarters of a mile. . . . The Indian tradition is, that the distance was formerly very small. . . .

The *Gull-Islands* are two small portions of land and rocks, lying N.E. of *Plumb-Island,* and were apparently once connected with it, and with each other. . . .

Fisher's-Island . . . is now comprehended within the town of Southold. There is a series of rocks, reefs, and shoals in a N.E. direction from the N.E. Gull-Island, about seven miles, until Fisher's-Island begins. Evidently these are the remains of the ancient continent, which many ages ago stretched across this space.

Thus writes one of the earliest observers in the region which we have to consider, and the first, so far as I am aware, to note the indications of former land connection between Long Island and the main land. His conclusions were, of course, drawn from general appearances only, but it will be of interest to note how they agree with the facts discovered and made known by subsequent observers, some of which facts it is the object of this paper to discuss.

PART I.

The phenomena connected with the distribution of our living floras and faunas have always interested and frequently puzzled, those who have tried to understand the meaning of many of the facts involved. The subject has been discussed by Gray, Wallace, Darwin, and other noted scientists, besides a number of other observers in all parts of the world, but the importance of the subject as a factor in the interpretation of geological phenomena has not received the attention which it deserves. The object of this contribution may, therefore, be considered as an effort to demonstrate, in regard to the region here discussed, how the facts connected with the distribution of its flora may be of aid in the solution of some of the problems connected with its geology, and ultimately, perhaps, to lead to similar observations and comparisons elsewhere.

The fact that certain geological formations support characteristic living floras, as readily to be recognized and differentiated as are the fossil floras contained in their rocks, has long been known and commented upon. That is to say, certain plants are recognized as being invariably associated with areas of certain geological formations. Such a condition prevails upon Staten Island, as noted by me some years since*, where the flora growing upon the cretaceous and that growing upon the drift are so remarkably distinct that the fact could not fail to attract attention. Similar facts were also noted by Dr. N. L. Britton in New Jersey†, and by others in more widely separated localities‡, and the few references here given will indicate, in a general way, the scope of such observations in the United States, in case it may be desired to learn more from them in regard to what has been done along this line of investigation.

Probably one of the best recognized and most characteristic of our eastern North American floras is the one generally known as the Pine Barren flora, which is such a prominent feature throughout the eastern and southern parts of New Jersey and southward. The northward extension of this flora through Staten Island and Long Island was made the subject of a paper

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* "Relations between Geological Formations and the Distribution of Plants." (Bull. Torr. Bot. Club, vii. 14, 15).

† Preface to "A Preliminary Catalogue of the Flora of New Jersey." (Geol. Surv. N. J., 1881).

‡ "The Geological Distribution of North American Forests." Thos. J. Howell. (Pop. Sci. Month. xxiii. 517-524.

"The Relation of the Flora to the Geological Formation in Lincoln County, Kentucky." H. A. Evans. (Bot. Gaz. xiv. 310-314), etc.

by Dr. N. L. Britton*, in which the following characteristic species occuring there are mentioned: *Magnolia glauca*, *Hudsonia ericoides*, *Ascyrum Crux-Andreæ*, *Ascyrum stans*, *Drosera filiformis*, *Arenaria squarrosa*, *Polygala lutea*, *Tephrosia Virginiana*, *Desmodium laevigatum*, *D. viridiflorum*, *Rubus cuneifolius*, *Crataegus parvifolia*, *Eupatorium rotundifolium*, *E. album*, *E. hyssopifolium*, *E. leucolepis*, *Aster spectabilis*, *A. nemoralis*, *A. concolor*, *Chrysopsis Mariana*, *C. falcata*, *Solidago puberula*, *Helianthus angustifolius*, *Coreopsis rosea*, *Gnaphalium purpureum*, *Gaylussacia dumosa*, *Andromeda Mariana*, *Kalmia angustifolia*, *Utricularia subulata*, *Ipomœa pandurata*, *Phlox subulata*, *Asclepias obtusifolia*, *Euphorbia Ipecacuanhœ*, *Quercus nigra*, *Q. prinoides*, *Q. Phellos*, *Spiranthes simplex*, *Juncus scirpoides*, var. *macrostemon*, *J. pelocarpus*, *Xyris flexuosa*, *X. Caroliniana*, *Cyperus cylindricus*, *Eleocharis melanocarpa*, *Stipa avenacea*, *Sporobolus serotinus*, *Glyceria obtusa*, *Panicum verrucosum*, *Andropogon macrourus*, *Cupressus thyoides* and *Lycopodium inundatum*, var. *Bigelovii*.†

To these a few others subsequently discovered may be added, such as *Quercus heterophylla*, *Q. Rudkinii*, *Helonias bullata*, etc., but the list, as it stands, is sufficient for the purpose of this paper.

Shortly afterwards Prof. W. W. Bailey called attention to the fact that many of the characteristic species were to be found to a limited extent, near Worden's Pond, in southern Rhode Island, giving a list of nineteen, and saying that other peculiar southern forms could be added.‡ Continuing along the coast into Massachusetts, the next locality which has received special attention from botanists, is the vicinity of New Bedford, and here we may note the occurrence of some twenty-five of the species previously enumerated, according to the catalogue of the plants of this region prepared by E. W. Hervey.§ As we proceed further northward and inland the number of these species become fewer and more scattered, and are finally reduced to such as might fairly be excluded from the list of characteristic pine barren plants, on account of their still further northward range; such as *Tephrosia Virginiana*, *Solidago puberula*, *Kalmia angustifolia*, *Asclepias obtusifolia*, *Juncus pelocarpus* and *Lycopodium inundatum*, all of which are reported from as far north as Canada.

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* Bull. Torr. Bot. Club. vii. 81-83.

† These species were taken from the "Flora of Richmond Co., N. Y.," N. L. Britton and Arthur Hollick, and "Catalogue of the Phaenogamous and Acrogenous Plants of Suffolk County," E. S. Miller and H. W. Young.

‡ Bull. Torr. Bot. Club. vii. 98, 99

§ "Flora of New Bedford and the Shores of Buzzard's Bay, with a Procession of the Flowers."

The occurrence of *Magnolia glauca* near Cape Ann is however so well known that exception would naturally be taken if mention of this southern species were neglected; but it need only be said in this connection that the fact of this tree being native at that locality has been questioned by those who are competent to express an opinion. John Robinson, who has written and published works upon the flora of that region*, says, on page 10 of "Our Trees": "Why the *Magnolia* should be found in Gloucester is a mystery. The 'Hermit,' a well-known Gloucester character, a student and lover of nature, feels sure that it was brought from the South, Virginia, perhaps, and planted in some old garden." If, however, the tree be truly native there, the fact is of the utmost significance, as will be appreciated when the geological discussion in the final portion of this contribution is considered.

The question which will now naturally arise is, how did this pine barren flora spread to the localities in New England where we now find it? It is a southern flora, and is characteristically American; few, if any of the species being known in the old world. Its course of migration was from the South, either by way of the mainland through New York and Connecticut, or else across the salt water from Long Island. If it came by way of the mainland we should reasonably expect to find evidences of its migration through New York and thence eastward through Connecticut. It might be urged, however, that these plants are mostly sand-loving species and that the soil throughout the region mentioned would not be favorable for their growth. Such is doubtless the fact and their almost entire absence from the region is not surprising. In fact, knowing the plants as we do, it would be very difficult to imagine them either becoming

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* "The Flora of Essex Co., Mass.," cloth, pp. 200.
"Our Trees," paper, pp. 120.

I have not thought it necessary to refer any more fully to works upon the botany of Massachusetts, but for the convenience of those who may wish to continue the comparisons and perhaps note further facts of interest, I have concluded to append the following list, from which the principal part of my information in regard to the flora was obtained:

"Flora of Fitchburg and Vicinity," Fitchburg Agassiz Assn.
"List of the Plants Growing Naturally in Milton, Mass." J. R. Churchill.
"Flora of Worcester Co., Mass." Jos. Jackson.
"List of Plants Found Growing Wild Within Thirty Miles of Amherst." N. A. Cobb.
"A Catalogue of Plants Growing Without Cultivation Within Thirty Miles of Amherst College." E. Tuckerman and C. C. Frost.
"A List of Plants Growing Without Cultivation in Malden and Medford, Mass., With Some Contributions to a Flora of Middlesex County." Middlesex Institute.

established or even migrating over such unfavorable soil. Careful search through the various published floras and lists of plants covering that region show but a few scattering species of those which have been enumerated as pine barren plants.* In no instance is there any such colony as we find in Rhode Island and southern Massachusetts. Their presence, therefore, in southeastern New England cannot be reasonably accounted for on the theory of migration by way of the mainland. The only other alternative is to admit that the plants have come to their present location by way of Long Island, and this supposes either a former land connection between that island and the New England coast in comparatively recent times—that is to say, since the Glacial Epoch--or else that the plants have jumped over wide stretches of salt water. In regard to the latter supposition it can only be said that it is against our previous general observation and experience, and would do violence to what has been observed in regard to the dissemination of plants. In this special instance, also, the prevailing winds and currents are both opposed to such a method of dissemination, the currents in particular being east and west, with a remarkably predominant westward tendency, as may be seen by the wear and tear of the eastern exposures of land and the transportation of the eroded material westward, where it forms the constantly lengthening spits and barrier beaches,

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* The flora of Connecticut has been poorly worked up compared to that of its adjacent States, but the following list will be of value to those who may wish to obtain details :

"List of Plants Growing Spontaneously in Litchfield and Its Vicinity." John P. Brace. (Am. Journ. Sci. iv. 69-89; 292-309), 1822.

"Catalogue of Phenogamous Plants and Ferns Growing Without Cultivation Within Five Miles of Yale College, Ct." Dr. Tully. (Appendix to E. Baldwin's "History of Yale College").

"Catalogue of Phenogamous and Cryptogamous Plants Found Growing in Meriden, Conn." Emily J. Leonard. (Trans. Meridan Sci. Assn. i., 1884, and sequel in 1885).

"A Catalogue of All Phenogamous Plants at Present Known to Grow Without Cultivation in the State of Connecticut." Jas. N. Bishop.

"Plants Found Growing in Meriden, Conn. Since Issue of the Catalogue in 1885." Mrs. E. B. Kendrick. (Trans. Meriden Sci. Assn. ii., 54-57.)

"A List of Forest Trees and Shrubs to be Found in Meriden, Conn." Chas. H. S. Davis. (Trans. Meriden Sci. Assn. iii., 46-78.)

"Notes on the Flora of Southwestern Connecticut." L. N. Johnson. (Bull. Torr. Bot. Club, xix., 88-91.)

If to these we add the "Flora of Westchester Co." O. R. Willis.

"Catalogue of the Phaenogamous and Acrogenous Plants Growing Without Cultivation Within Five Miles of Pine Plains, Dutchess Co., N. Y." Lyman H. Hoysradt. (Supplement Bull. Torr. Bot. Club, vi.)

"Revised Catalogue of Plants Growing Within Thirty Miles of New York City." (Bull. Torr. Bot. Club, years 1870-1874.)

"Preliminary Catalogue of the Anthophyta and Pteridophyta Reported as Growing Spontaneously Within 100 Miles of New York City." Torrey Botanical Club.

And "Catalogue of Plants Found in New Jersey." N. L. Britton. (Vol. ii., Part I., Geol. Surv. N. J. (1889, pp. 25-642), a fair idea of the botany of the region under discussion may be obtained.

which are particularly prominent on Cape Cod, Martha's Vineyard, Nantucket and the south shore of Long Island. In many instances, single species, mostly by the aid of man, have spread under such conditions, but never in any considerable number, especially such as are under consideration. In fact, the species in question generally disappear with the advent or continued presence of man, and this, as is well known, has been the case to a very appreciable extent in several of the localities within the area of our investigation.

Following out our line of argument, we would be forced to the conclusion that if continuous land connection once existed and any fragments of it remained, these ought to carry with them some evidences of their former relationship. The islands to the east of Long Island Sound (Gardiner's Island, Plum Island, Gull Islands, Fisher's Island, the Elizabeth Islands, Block Island, Martha's Vineyard and Nantucket), naturally, in fact almost irresistibly suggest themselves in this connection, even to the most superficial observer of any ordinary map of the region, and if the coast survey charts, showing the submarine shoals and contours are studied, their significance becomes irresistible. A study of the flora of these islands ought, therefore, to be of great assistance in solving the problem at issue. Unfortunately their native vegetation has suffered from the inroads of man to such an extent that we can form little or no idea of what it once was, in many instances. Thus, in regard to Penikese Island, the flora of which was compiled by Prof. D. S. Jordan as long ago as 1874*, he says : "Altogether it is about as barren looking a pile of rock and stone as one could well imagine."

Block Island has suffered in the same way†, and Martha's Vineyard and Nantucket show but a limited flora at the present day compared to that which once covered them. An exceedingly interesting account of the flora of this latter island has been written by Maria L. Owen, which gives not only a complete list of the plants, but memoranda in regard to their past abundance, recent destruction, etc. In it may be noted the names of some twenty-five of the pine barren species, besides many others not classed as such, but showing unmistakably their affinities with the far off Long Island shores, distant some

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* "The Flora of Penikese Island." (Am. Nat. viii. 193-197.)

† "Notes on the Flora of Block Island." W. W. Bailey, in mss. "Trees of any sort are extremely scarce. Those there are, appear, with rare exceptions, to have been planted."

eighty miles, instead of with the near-by coast of New England, not more than twenty miles away.*

We therefore have to consider the fact of a characteristic flora, whose principal habitat is on the mainland southward, extending from New Jersey on to Staten Island, thence on to Long Island and the islands to the eastward, and then reappearing on the mainland again in a limited area in southeastern New England. We have further to consider the significant fact that while in its northward extension it is a coast flora entirely, southward it exists not only near the coast, but over an area many miles inland. This significance will be better understood and appreciated when the geology of the region comes to be discussed. Considering the flora alone we might readily imagine a continuous strip of mainland to exist through the region now occupied by it, while Connecticut, with its little adjacent areas of New York and New Jersey would represent a more or less isolated island.

What, then is the most reasonable explanation of these botanical facts which we have established? Suppose we see what the geology of the region can tell us.

PART II.

During Cretaceous and Tertiary times a series of fresh water or estuary and marine deposits (clays, sands, gravels and marls) were laid down along the eastern borders of the North American continent. About the close of the Miocene, or the beginning of the Pliocene period, an era of elevation began which finally raised them hundreds, in places thousands of feet, above their present level, forming a vast coastal plain, which extended over the entire area where we now find them, and for a considerable distance eastward, into what is now part of the

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* "Catalogue of Plants Growing Without Cultivation in the County of Nantucket, Mass."

"The Pine barrens, although farther south, are of similar structure, and Nantucket, as regards its flora, seems like a piece of New Jersey moved up the coast for the convenience of northern amateurs in botany, who cannot get away from business long enough to go collecting in that State . . . Trees are lacking except in stunted form, and there are few of those, yet the tradition is that the island was well wooded when the first settlers came in 1659 . . . Some wood plants probably died out soon after the trees that sheltered them were gone; but even now Nantucket, though treeless, is not a flowerless isle . . . The island flora interests all botanists from its peculiarity . . . they are surprised at the occurrence of species not to be expected in this latitude . . . some belong to more northern localities, but these are far less numerous than the southern plants, some of which have never been found elsewhere in New England."

bed of the Atlantic ocean.* On the land side this plain was bounded by the crystalline and Triassic rocks of Connecticut, southern New York, New Jersey, Pennsylvania and southward, as may be seen by an examination of any good geological map of the eastern United States. The evidence of its extension northward around Rhode Island and Massachusetts are now almost obliterated, but there seems to be every reason to believe that its land limits were approximately the coast line of the present day. In fact, a small isolated portion of the old coastal plain still exists apparently in the vicinity of Marshfield, Mass., as indicated by Edward Hitchcock in 1841†, and recently by N. S. Shaler, in a paper read before the Geological Society of America.‡ It might also be added, by way of parenthesis, that similar indications are to be looked for elsewhere, notably on Cape Cod and near Gloucester, especially in case it should be determined that *Magnolia glauca* is truly native at this latter locality, although Prof. Shaler does not mention any such in his account of the geology of Cape Ann.§ Further north than Massachusetts, so far as I am aware, it is not even indicated, and except for the presence of the well-recognized submerged plateau off our eastern shores all further trace of the former coastal plain is lost. Its eastern limits, where it formerly met the waters of the Atlantic ocean, were probably where we now find the borders of this plateau to be, namely, at the 100 fathom contour.

Shortly after the advent of the Ice Age the elevation had reached its maximum. The rivers had previously cut deep valleys through the easily eroded material forming the coastal plain, in their courses to the sea, and when the continental glacier, pushing its way southward and eastward, finally flowed over the edges and escarpments of the hard crystalline rocks onto the soft and incoherent material of the coastal plain it

* Up to this point I believe all authorities are agreed. In regard to subsequent geological changes, and the interpretation of certain recognized facts, a variety of views are held, many of them contradictory to one another, so that an impartial statement, without more or less discussion, becomes almost an impossibility. I shall, therefore, set forth my own views freely, with brief references to those of others, leaving further discussion of the subject for some future papers, which are now in course of preparation. The present contribution, so far as the geology is concerned, may therefore be considered as a prelude, and many points which are here somewhat summarily treated, it is hoped to consider more fully later on.

† "Final Rept. Geol. Mass." ii., 427.

‡ "Tertiary and Cretaceous Deposits of Eastern Massachusetts." (Bull Geol. Soc Am. i., 443-452.)

§ 9th Ann. Rept. U. S. Geol. Survey, 528-611.

scooped it out to a great depth in places, and then, either carrying it forward in mass, or else pushing and squeezing it ahead in a great contorted ridge*, capped by the bowlder till, finally left it as part of the terminal moraine. Wherever these conditions have prevailed we find the phenomena to be the same, and Long Island may be considered as one of the grandest object lessons in this connection.

Just when the period of elevation ended and that of depression began, in fact, whether it was previous to, or subsequent to that of greatest ice accumulation, is yet a matter of controversy between authorities, but in either case on the retreat of the glacier, we may picture to ourselves the terminal moraine forming an elevated ridge extending through Staten Island, Long Island and the islands to the eastward, forming a continuous. more or less, elevated land connection to the north and east, with what remained of the coastal plain sloping away from it on one side and a trough filled with the water from the melting glacier on the other. It is probable that the ridge represented by Orient Point, Plum Island, Gull Islands and Fisher's Island may be the remains of an independent second glacial moraine, as urged by Warren Upham† and N. S. Shaler‡, but the discussion of this fact need not now concern us.

The old river valleys had become blocked up with the débris of the moraine, and the waters had to seek other outlets. These would naturally be where they first began to overflow the rim of the trough in which they were imprisoned. One of these would probably be through the old channel of the East River, which was to the north of the terminal moraine, and, therefore, comparatively free from obstruction. From here the waters would join those of the Hudson, which had doubtless ere this forced its way, through the morainal barrier and was again occupying its old channel. Others are indicated to the eastward

* Dr. Fredk. J. H. Merrill was, I believe, the first one to thus interpret this phenomenon on Long Island; for which see his paper "On the Geology of Long Island." [Ann. N. Y. Acad. Sci. iii., 341-364.] It has been made the subject of careful personal examination in the vicinity of Glen Cove, and similar effects were subsequently noted by me and Dr. N. L. Britton on Staten Island. [See Proc. Nat. Sci. Assn. S. I., Nov. 8, 1884, and Trans. N. Y. Acad. Sci. xi., 101.] Although so far as Long Island is concerned these views are not considered tenable by Prof. J. D. Dana. [See "Phenomena of the Glacial and Champlain Periods about the Mouth of the Connecticut Valley in the New Haven Region." Am. Journ. Sci. xxvi., 341-361; xxvii., 113-130.] And they are rejected as inadequate on Martha's Vineyard, according to Prof. N. S. Shaler. [See "Report on the Geology of Martha's Vineyard," 7th Ann. Rept. U. S. Geol. Surv., 296-363.)

† "Terminal Moraines of the North American Ice-Sheet." (Am. Journ. Sci xviii., 81-92; 197-209.)

‡ "Report on the Geology of Martha's Vineyard." (7 "Ann. Rept. U. S. G. S., 296-363.)

through what are known as Plum Gut and The Race, where a depth of over fifty fathoms is found, which would soon become sufficiently eroded to nearly empty the trough and convert it into a broad river extending east and west, until, with subsequent subsidence the sea could enter and gradually transform it into the Sound as we now know it. Such a river channel is clearly indicated in the soundings made by the coast survey, as pointed out by Prof. J. D. Dana*, and as may be seen by a study of the coast survey chart of the region.† If the depths were relatively the same then as now the first outlets would have been to the eastward, but as tidal erosion has proceeded much more rapidly there than at the western outlet, due to the more easily eroded strata, it is not safe to assume this, and I am inclined to think that the outlet was wholly at the western end for a considerable period, until the subsidence was sufficient to cause a break to be made through the eastern end of the moraine, and permit the sea to enter. Tidal scouring would then soon effect the depths which we see at Plum Gut and The Race.

The present rate of coastal subsidence, as calculated by Prof. Geo. H. Cook,‡ and other authorities, is about two feet per century. At this rate, six thousand years ago practically the whole of the area included within the present twenty fathom contour would have been above sea level—only the deepest parts of the trough of the Sound being below it—one place near Eaton's Neck showing thirty-two fathoms and another near Horton's Point reaching a depth of twenty-seven fathoms. This area, as may readily be seen, includes the whole of Staten Island, Long Island, Block Island, Martha's Vineyard and Nantucket, besides a respectable portion of the submerged coast eastward and southward. It is also probable that at least a part of this area to the eastward, which at the present time is lower than the twenty fathom contour, has become disproportionately so in modern times by tidal scouring, and that it was actually and relatively higher formerly than now.

Under these circumstances we should, therefore, have had, during a considerable period of time, a continuous strip of land, except for the river outlets, all the way from New Jersey to Massachusetts, separated from the mainland by a body of

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* "Long Island Sound in the Quarternary Era., etc." (Am. Journ. Sci., xl., 425-437.)

† "General Chart of the Coast no. viii. Approaches to New York, Gay Head to Cape Henlopen." U. S. Coast Survey.

‡ "Final Rept. Geol. N. J." (1868), pp. 343-373.

water occupying the trough scooped out by the glacier, which, in its present depressed and widened condition, we now call Long Island Sound, but which was then a fresh water lake or broad river.* Bearing these conditions in mind we next have to consider the still further subsidence of the Champlain Period, the re-elevation of the Terrace Period, and the depression which is again going on at the present day. It is evident that at some time during these oscillations of level the sea, having eaten away the coastal plain, finally reached the barrier of the terminal moraine, where this still remained as the connecting link between Long Island and Massachusetts. The moraine gave way in places, channels were formed and detached portions remained to form the islands which we recognize to-day as Block Island, Martha's Vineyard, Nantucket and the host of other lesser islands which stream out from the end of Long Island towards Cape Cod and the Rhode Island shore, while the eroded portions are represented by the great submerged ridges which are known as the Nantucket and other shoals.

Whether there were more than one oscillation of level before the final separation was accomplished need not here be discussed, but it is evident that our theory implies the continued existence of land connection, between New Jersey and southeastern New England, by way of Long Island, during a sufficient period of time after the final recession of the glacier, for the pine barren flora to have spread and become established there, and we may even approximate, with some measure of probability, what that period of time may have been. The vast time ratios formerly considered necessary by geologists are gradually but surely giving way to more moderate estimates, and it is of interest to note that from six to ten thousand years is the latest accepted calculation of the time which probably elapsed since the final recession of the glacier, by one of our most acute and conservative authorities†—a period which, as we have seen, is about coincident with the probable time when the area bounded by the twenty fathom contour was above the sea level. It is needless to point out that it also implies no subsequent submergence of the remaining portions of this land since the flora was established. In other words, Long Island, Block Island,

* Dr. Fredk. J. H. Merrill concluded, from the distribution of the morainal material, that the trough of the Sound was in existence and filled with water previous to the advent of the glacier [Geology of Long Island, Ann. N. Y. Acad. Sci. iii., 359], but I believe that the facts which he quotes to substantiate this theory are capable of modification and of being otherwise interpreted.

† "Estimates of Geologic Time." Warren Upham. (Am. Journ. Sci. xlv., 209-220 (1893).

Martha's Vineyard, Nantucket, etc., as we now know them, have not been submerged since the final retreat of the glacier, and their separation into islands by the submergence of the intervening land is a comparatively modern phenomenon, due to the depression and erosion which are actively at work, and which have produced such conspicuous results during the historic period. Such a conception would bring the geology of the entire coastal region into harmony; would imply a single series of causes and effects, and would not necessitate the introduction of any unusual or extraordinary phenomena in any particular locality.

I have unfortunately not had the opportunity to visit either Block Island, Martha's Vineyard or Nantucket, but from the published descriptions and the accounts which have been given me by those who have, besides the study of such material from these islands as I have had access to, has convinced me that the conditions there are entirely comparable to such as I am familiar with on Staten Island and Long Island, and that there is no necessity for invoking any other series of cause and effect, or of treating them, and the phenomena connected with them as isolated subjects; such, for instance, as their special elevation by mountain making processes and other theories which have been advanced to account for the contorted condition of the strata on these islands. In this connection, reference should be made to the articles by Prof. N. S. Shaler*, but as previously intimated, these and several facts which have come to light since they were written, it is hoped will be discussed in subsequent papers.

Amongst numerous other published articles which refer to the region here considered may be specially mentioned the following:

Assembly Document No. 161, Feb. 11, 1837. Communication from the Governor relative to the geological survey of the State. First Ann. Rept. 1st Geol. Dist., Wm. W. Mather, "Encroachment of the Sea," pp. 74, 75.

Assembly Document No. 200, Feb. 20, 1838. Same title and subject, pp. 132, 133.

"On Water Courses of Long Island." Elias Lewis, Jr. (Am. Journ. Sci. xiii., 142–146.)

"Certain Features of the Valleys or Water Courses of Southern Long Island." Elias Lewis, Jr. (Am. Journ. Sci. xiii., 215, 216.)

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* "Report on the Geology of Martha's Vineyard." (7 "Ann. Rept. U. S. Geol. Surv., 296–363.)
"The Geology of Nantucket." (Bull. No. 53, U. S. Geol. Surv.)

"Geological History of New York Island and Harbor." J. S. Newberry. (Pop. Sci. Month. xiii., 641–660.)

"Geology of the Sea Bottom in the Approaches to New York Bay." A. Lindenkohl. (Am. Journal. Sci. xxix., 475-480.)

"Notes on the Sub-Marine Channel of the Hudson River and Other Evidences of Post-Glacial Subsidence of the Middle Atlantic Coast Region." A. Lindenkohl. (Am. Journ. Sci. xli., 489-499.)

"On the Post-Glacial History of the Hudson River Valley." F. J. H. Merrill. (Am. Journ. Sci. xli., 460-466.)

"Recent Fossils near Boston." Warren Upham. (Am. Journ. Sci. xliii., 201-209.)

NOTE.

[Since completing this paper my attention has been called to two articles, to which, in closing, I shall take the liberty of referring.]

In a pamphlet of 18 pages, entitled "The Geological Formation of Long Island, New York, with a Description of its Old Water Courses," written by John Bryson and published in 1885, the author discusses the origin of the stratified and superficial deposits of the island, and amongst his conclusions, arrived at from a study of these deposits, are the following:

"At the close of the glacial age, the island was doubtless connected with the mainland, and that this state of things existed until the East River channel was formed; this had the effect of draining the old sub-glacial streams.

"There is no evidence of any oscillation of any part of the island subsequent to the glacial age, the formation, in general, remaining very much the same as it came from the hand of the glacier."

The second contribution, from the same author, may be found in the American Geologist, xi., 210-212 (March, 1893), where he notes the apparent unity of conditions on Long Island and Martha's Vineyard, reaching similar conclusions to those here advanced, but reasoning from different premises.

CHARTS AND MAPS USED.

U. S. Coast Survey Chart, No. VII. Cape Ann to Gay Head.

U. S. Coast Survey Chart, No. VIII. Gay Head to Cape Henlopen.

Map of Long Island and southeastern New England, by the writer.

PETROGRAPHY OF THE GNEISSES OF THE TOWN OF GOUVERNEUR, N. Y.

BY C. H. SMYTH, JR.

INTRODUCTION.

In a previous communication* the writer has given a brief description of the main geological features of a portion of the towns of Gouverneur and Fowler, St. Lawrence County, New York. It is the aim of the present paper to set forth briefly the petrographic characters of the formations there discussed. Rocks, which, like the limestone and sandstone, though of great stratigraphic importance, are comparatively simple and uniform in composition, receive little attention ; while considerable space is sometimes given to rocks of limited extent, but of more interest from a petrographic standpoint. It is hoped that the facts here recorded may be of value as a basis for comparison in future work on the geology of the Adirondack region. The writer is indebted to the Geological Department of Columbia College for the grinding of all rock-sections used in the preparation of this paper, and takes pleasure in expressing his appreciation of this material assistance.

GNEISS.

While as a whole the gneiss presents a great sameness over wide areas, still local variations are so numerous and diverse that the limits of this paper would hardly suffice for their description. Therefore, only the general character of the gneiss, together with a few of its more important modifications, will be described.

The color of the unweathered gneiss is generally gray, less often red, and varies from this to black, the latter color being confined to distinct layers and lenticular patches. The banding and foliation vary greatly, being sometimes marked and again wholly absent. Thus considerable areas in the gneiss have all the characters of granite, and this is commonly the case with hand specimens.

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* "A Geological Reconnoissance in the Vicinity of Gouverneur." N. Y. Trans. N. Y. Acad. Sci., XII., p. 97.

Under the microscope the gneiss shows a mineral composition seldom very different from that of the granites, though, as a rule, containing more plagioclase. Slides from different localities show no great variation in the character of the minerals present, though different proportions prevail. Even the dark bands are usually composed of the same minerals as the normal gneiss, but with a larger content of mica or hornblende. There are, however, exceptions to this rule. Quartz, orthoclase, plagioclase, biotite and hornblende make up the bulk of the gneiss; with zircon, apatite, ilmenite, magnetite, rutile, garnet and sillimanite as minor constituents.

Quartz is never absent, though varying somewhat in quantity. It often occurs in rather large patches, which under crossed nicols break up into several distinct parts. Fluid inclusions are very abundant, usually in bands which extend through adjacent individuals. Zircon is also a common inclusion, while the hair-like bodies supposed to be rutile are rarely present. The quartz nearly always shows undulatory extinction, which, together with the shattering often apparent, bears witness to the strains to which the rock has been subjected.

The feldspars show much variation in the relative proportions of different species present. On the whole, plagioclase seems rather more abundant than orthoclase, but the reverse is so often true that the examination of a larger number of sections might show it to be the rule. In a few instances microcline is an abundant constituent, but it is more generally absent. A very marked feature in a majority of the sections examined is a great abundance of the microperthitic intergrowth of orthoclase and plagioclase. The peculiar banded, dotted and striated sections produced by it are generally apparent in ordinary light, but are brought out more clearly with crossed nicols. Sections of orthoclase show a varying proportion of their area occupied by slender spindle-shaped masses of plagioclase. These spindles extinguish simultaneously, and have decidedly stronger double refraction than the surrounding orthoclase. In most instances the microperthite has the appearance of a contemporaneous crystallization of two feldspars; but enough sections contain absolute proof of its secondary nature to render it extremely probable that in this gneiss it is never an original intergrowth. Evidence of this secondary origin is seen in plagioclase spindles passing unbroken across cracks in the orthoclase, and in the evident optical continuity of the material of the spindles with secondary feldspar filling cavities and cracks adjacent to the microperthite. Figure 1 shows a case of the latter kind. A crack between quartz and orthoclase is filled by secondary plagioclase, which sends out branches into the orthoclase, forming incipient microperthite. The plagioclase, represented by shading, gives a blue interference color, and all the areas extinguish simultaneously. The original orthoclase gives a yellow interference color.

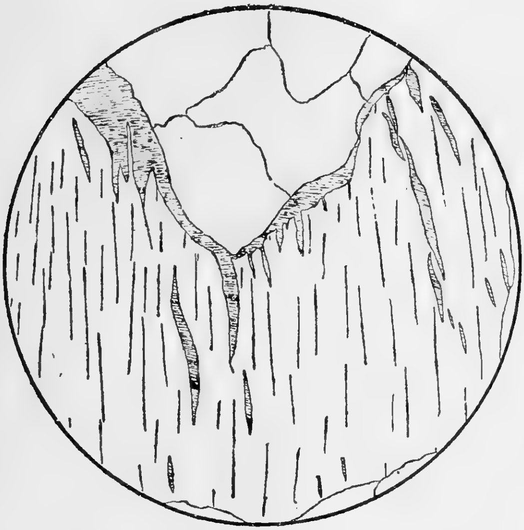

Fig. 1. Secondary microperthite.

Secondary feldspar (shaded) filling crack between quartz and orthoclase and with the latter forming microperthite.

Diameter of field, 0.7 min.

Along many of the cleavage cracks there are very narrow bands of the secondary feldspar, perceptible only with a high power. As the bands increase in width they naturally show less dependence upon the cleavage cracks, though a general parallelism remains.

From such facts it is evident that the microperthite results from the development of plagioclase along planes of solution in orthoclase, these planes of solution being determined chiefly by cleavage. Much of the material of the secondary feldspar is doubtless derived from the orthoclase, while a certain portion is brought from without. Similar developments of secondary microperthite have been described by Klockmann*, Lehmann†, Lacroix‡, Romberg§, Hobbs||, and others. The fact that the secondary feldspar fills cracks in the rocks shows that at least part of the microperthite has been formed subsequent to the period of dynamo-metamorphism. On the other hand, no instance has yet been found where the secondary feldspar has itself been fractured. Thus, so far as it goes, the evidence is in favor of the supposition that the formation of microperthite is a chemical process, which goes on in great part subsequent to fracturing and crushing of the rock. But whenever formed, microperthite is now so abundant that its development must be regarded as one of the most important factors in the history of the rock.

Like the quartz, the feldspar gives evidence of mechanical deformation in a more or less complete shattering, in undulatory extinction, and in the bending and breaking of the twinning lamellæ of the plagioclase.

Quartz and feldspar together make up a large part of the ordinary gneiss, the other constituents being present in much smaller proportions. Of the ferro-magnesian minerals biotite is rather the most abundant in the slides examined, with hornblende approaching it in quantity. The biotite forms very irregular masses, with the usual strong pleochroism. It is characterized by an abundance of pleochroic halos, which are usually quite independent of perceptible inclusions. It shows a strong tendency toward alteration, the color changing to green, while the surface becomes dusty. A complete alteration to chlorite is, however, rarely apparent.

Hornblende forms irregular masses, sometimes prismatic, of dark green color with decided pleochroism. Except in one or two sharply defined cases, there is nothing to indicate that the hornblende may be uralitic. It is evidently one of the oldest of rock constituents.

In three or four sections of the ordinary gneiss pyroxene occurs in irregular grains, but is not of sufficient importance to be regarded as an essential mineral.

Iron oxides are represented by finely divided hematite in the red feldspars; by limonite in cracks and fissures; by magnetite

* Zeits. Deutsch. Geolog. Gesell. XXXIV., p. 381.

† "Untersuchungen ueber die Entstehung d. Altkrystal. Schiefer," p. 217.

‡ Bull. Soc. Min. Fr. IX., p. 131.

§ Neues Jahrbuch fuer Mineralogie, etc., B. B. VIII., p. 300.

|| Bull. Geol. Soc. America, IV., p. 171.

in grains and crystals ; but most abundantly by ilmenite. This mineral is seen in nearly every section, often in grains of considerable size. In some cases it is perfectly fresh, in others the cleavage lines and boundaries are marked by white or yellowish leucoxene. When this alteration has reached its limit, there is left only the leucoxene, either in an irregular mass or forming a network with the angles of the cleavage of ilmenite. Zircon occurs in irregular fragments and in stout prisms.

In structure the gneiss varies from a coarse holo-crystalline granular, or granitic, to a fine mosaic made up of fragments of the constituent minerals. Between these two extremes there is every possible stage. By far the larger number of sections show the quartz and feldspar in rather large masses surrounded by the finer mosaic of fragments. A resemblance to porphyritic structure is sometims produced in this way, particularly when, as occasionally happens, there has been considerable recrystallization of the finer fragments.

Variations from the normal gneiss are, as already stated, quite abundant, but can be mentioned only briefly. A garnetiferous gneiss was seen at several points, differing from the ordinary gneiss chiefly in containing large quantities of garnet. This mineral forms irregular masses of considerable size. Under the microscope it has a decided pink color, and is quite fresh, showing only a slight development of chlorite along cracks. This variety of gneiss often contains an abundance of sillimanite in long slender crystals. The mineral is not evenly distributed through the rock, but is grouped in nests, in which the individual crystals are often roughly parallel. While these nests may penetrate quartz, there is a marked tendency for the sillimanite to occur in the garnet. Sometimes only the outer portion of the latter mineral contains sillimanite, but often the slender prisms penetrate the entire mass of garnet.

The black bands and lenses that are so conspicuous in the light colored gneiss are commonly composed of the constituents of the ordinary rock, with the dark minerals in unusually large quantities. They are sometimes hornblendic and sometimes micaceous, while in some instances ilmenite is an important constituent. One such dark band occurring in garnetiferous gneiss is quite different from the others examined. It is a nearly black, micaceous, distinctly schistose rock, of medium grain. Sections show a holocrystalline aggregate of plagioclase, a little orthoclase, monoclinic pyroxene, and hornblende ; with apatite, zircon and pyrite as minor constituents. None of these minerals, except the apatite, show crystal outlines.

The feldspars are quite fresh, but show decided mechanical deformation in the bending and breaking of twinning lamellæ and very marked undulatory extinction.

The pyroxene is colorless or pale green, with extinction angle of about 45°. There is a certain amount of alteration to chlorite, but the most noticeable change is the passage into dark green uralite. The uralite, as a rule, makes up only a small part of the individual, but in a few cases has replaced most of the pyroxene. Besides the uralite there is present a small amount of hornblende, which seems to be original.

Biotite is present in large quantities, partly in large plates, and partly in small scales of secondary origin.

The relation of the dark band to the surrounding rock is such that it must be regarded as belonging to the gneiss just as much as the other dark bands; and yet from its mineralogical composition there can be little doubt that it is intrusive. The same explanation must apply to many of the dark bands, though it is not often so clearly indicated.

GRANITE.

There is evidence of a long time break between the gneiss and the granite, with corresponding structural differences; but in mineralogical composition there is considerable similarity between the two rocks, the most marked difference being the greater amount of plagioclase in the gneiss.

The granite is usually of a light gray color, and of rather coarse grain, but there are many wide variations from this general type. Similar variations occur in its mineralogical composition; the rock being, as a rule, a biotite granite, or granitite, but showing many local transitions into pegmatite, tourmaline granite, hornblende granite, diorite, etc.

The quartz of the granite is either clear white and colorless, or milky, the latter appearance being due to the presence of abundant fluid inclusions. The microscope shows, in many instances, besides these fluid inclusions, slender, black, hair-like bodies usually regarded as rutile. These vary considerably in number, size and arrangement. In some sections they are scattered quite irregularly through the quartz, while in others they show a tendency towards parallelism. In a single case the hairs form two distinct groups. The first consists of quite short bodies scattered very irregularly through the quartz. The second group consists of unusually long hairs, so arranged as to form a network with square meshes. The hairs of the net are more abundant in one direction than the other, the most numerous making an angle of 5°, with the axis of greatest elasticity in the quartz.

In nearly all sections the hair-like bodies are more or less bent, broken and stretched apart. Sometimes it is evident that this results from a crack through the quartz, but more often it is impossible to detect any sign of such fracture. Apparently the quartz has been sufficiently plastic to yield to strains which broke the rutile.

Inclusions of zircon and other small crystals or fragments in the quartz sometimes show several short cracks radiating from them. A similar occurrence is also seen in the feldspar. In the case of cracks radiating from hornblende in a porphyritic rock Becker* has suggested that they might result from the forcible expansion of the hornblende in process of growth. But in the present instance it seems more probable that they result from the unequal resistance offered by the included mineral and the quartz or feldspar to the pressure to which the rocks have been subjected. Other effects of pressure are seen in the marked undulatory extinction always present, in the more or less shattering of the quartz, and in the development in it of abundant secondary fluid inclusions.

There is wide variation in the character of the feldspar. In the normal granitite orthoclase is most abundant, in the granulitic variety microcline is often conspicuous, while in the more basic granitite and diorite a basic plagioclase replaces the more acid species.

Microperthite is common, though rather less so than in the gneiss. Feldspar is also sometimes intergrown with quartz, forming micropegmatite. As is usually the case†, this micropegmatite fills small spaces between the larger rock constituents, and is evidently of late formation. In many instances it is clearly secondary, having formed in cracks made by disturbances subsequent to the solidification of the rock. So often is this true that it is highly probable that all of the micropegmatite is of secondary origin. Enough instances of each secondary formation of micropegmatite have been described‡ to indicate that it is a general, rather than exceptional, phenomenon.

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* Becker, G. F., "Quicksilver deposits of the Pacific Slope," p. 100.

† Rosenbusch, Mic. Phys. Mass. Gest., p. 39.

‡ Irving, R. D., "The Copper Bearing Rocks of Lake Superior." Monograph V., U. S. G. S., p. 114.

Judd, J. W., Quart. Jour. Geol. Soc., XLV., p. 175-186. Ibid. XLII., p. 72.

Romberg, J., Neues Jahrbuch, fuer Mineralogie, etc., B. B. VIII, p. 314-323; 374-378.

Hobbs, W. H., Bull. Geol. Soc. America, IV., p. 171.

In other cases the different areas of quartz in the feldspar are wholly independent of each other, producing the structure to which the term micropoikilitic* has been applied.

Beyond the development of microperthite and a varying amount of cloudiness, the feldspar, as a rule, shows no decided alteration. Muscovite and chlorite have been rarely produced at the expense of feldspar, but not in sufficient quantity to exert any influence upon the character of the rock.

Like the quartz, the feldspars show much evidence of mechanical strains. Undulatory extinction is quite general, often accompanied by granulation, either peripheral or extending through entire individuals. In the plagioclase there is much bending and breaking of twin lamellæ, while the development of twinning by pressure is often seen.

In the normal granite, biotite is the only ferro-magnesian mineral, and varies greatly in quantity, often being entirely absent. It is dark brown, strongly pleochroic, and fairly fresh as a rule, though sometimes bleached. Pleochroic halos are abundant, often extending through an entire fragment of the mineral, and showing no dependence upon inclusions. Besides the original biotite the very basic phases of the granite contain small amounts of biotite that is clearly of secondary origin.

The distribution of hornblende in the granite is very limited being confined to the basic segregations which have the composition of diorite. In these, hornblende is the prevailing ferromagnesian mineral. It never shows any decided crystal outline, though occasionally in the form of an imperfect prism. It is dark green, strongly pleochroic and usually very fresh. In one section it is associated with a considerable amount of light green monoclinic pyroxene. A parellel growth with biotite is common.

Tourmaline characterizes, by its presence in considerable quantities, a few limited areas of granite. It occurs in the ordinary prism with triangular cross section, or in irregular masses. The color is brown or green, sometimes in zonal arrangement, and the pleochroism intense.

The ordinary minor constituents of granite, such as apatite, zircon, ilmenite, leucoxene, etc., are present in varying quantities, but need not be described.

The granite shows several phases which differ considerably from the normal type of the rock. Coarse pegmatitic varieties are abundant, both associated with the ordinary rock and forming independent masses. In the latter tourmaline is sometimes

* Williams, I. H., "On the Use of the Terms Poikilitic and Micropoikilitic in Petrography," Journal of Geology, I., p. 176.

so abundant as to make them true tourmaline granites. Another phase, which has been distinguished as granulite* (perhaps unfortunately, as it lacks the foliation of a typical granulite), occurs at many points. It is fine grained and white, resembling sandstone. Under the microscope it is seen to be a mosaic of quartz and feldspar, with numerous larger individuals of garnet. There is wide variation in the character of the feldspar, but microcline is often conspicuous.

The garnet usually shows crystal outlines, though irregular grains are also present. It has a decided pink color and inclusions are abundant. These have, as a rule, the shape of negative crystals, and are more or less concentrated toward the centers of the crystals. With the exception of some apatite and zircon, other minerals are lacking. The field relations of the granulite and ordinary granite show a perfect continuity between the two rocks, and suggest that the two varieties are due to a differentiation of the original magma. But under the microscope the granulite shows a marked cataclastic structure, together with a large amount of secondary quartz and feldspar. It has clearly been formed from the ordinary granite by the shattering of the constituents of the latter rock, attended by a large amount of recrystallization.

In one portion of the granitic area there are several alternations between the ordinary granite and a very dark rock composed of hornblende, biotite and plagioclase—a quartz-free diorite in composition, though lacking the structure of a typical diorite. The passage from the ordinary granite to this dioritic variety is very gradual, there being no break whatsoever between them, and there can be no doubt that the diorite is a basic segregation from the original magma.

The effects of dynamo-metamorphism upon the granite, while almost always apparent, are not, as a rule, very conspicuous. The bending, stretching and crushing of minerals have been mentioned, but these effects are generally to be seen only with the aid of the microscope. Small areas of the rock, however, often show incipient foliation, and at some outcrops the granite passes into a true gneiss, which is, however, entirely distinct from the older gneiss previously described. The formation of granulite has already been mentioned. As to why the granite sometimes changes to gneiss and sometimes to granulite, there is no very clear evidence. But comparison of sections of the two varieties indicates that the granulite results from a more complete shattering of the granite, to which, with the absence

* Trans. N. Y. Academy Sciences, XII., p. 105.

of mica and the large amount of recrystallization, is due the lack of foliation. That the garnet has been formed at the expense of biotite originally present is not improbable.

The contact of granite with crystalline limestone has produced some noticeable changes in the latter. Most apparent is a whitening of the rock, with an increase in the coarseness of grain. At the same time scales of graphite and mica become larger and more abundant, while knotty masses of silicates develop to a considerable extent. Microscopic examination of these shows the presence of biotite, muscovite, tremolite and a colorless pyroxene. These minerals are crowded together in such a way that there is no opportunity for the development of crystal boundaries. Similar lumps of silicates are by no means wanting in the limestone at a distance from the granite, but near the latter rock they have developed in unusual abundance. On the whole the contact phenomena are not very marked, and some of the minerals most common in granite-limestone contacts are absent.

CRYSTALLINE LIMESTONE.

The limestone is, on the whole, quite uniform in composition and structure, though variations from the normal type produced by the presence of different minerals, are common. The normal rock is coarsely crystalline, varies from white to dark gray, and contains abundant mica and graphite. Weathering gives a darker color to the surface, while the cleavage faces become roughened by parallel ridges, due to solution along basal twinning planes.

Pyroxenic phases of the limestone are quite common. The pyroxene is, as a rule, colorless, and has a high extinction angle. It seldom shows distinct crystal outline, being in irregular grains of small size. Tremolite is also found, occurring in a similar way, but seemingly less abundant than pyroxene. Probably genetically connected with these phases of the limestone is the serpentineous variety, though the connection has not been absolutely proved. The serpentine forms rounded grains in the rock, sometimes equalling the calcite in quantity. Merrill * has shown for similar rocks in Warren County that the serpentine is derived from pyroxene. In the present instance no serpentine has been found containing a core of pyroxene; but its structure is often such as would result from its derivation from pyroxene, or from hornblende, and as these

* Merrill, G. P. On the Ophiolite of Thurman, Warren Co., N. Y., with remarks on the *Eozoon Canadense;* Am. Jour. Sci. III., XXXVII, p. 189.

minerals are so abundant in the rock there can be little doubt that they are the source of the serpentine.

Another phase of the limestone shows, scattered through the mass, imperfect prismatic crystals, averaging about an inch in length, and dark gray or black. On weathered surfaces these crystals project from the rock surface, but are themselves much decomposed. Under the microscope the mineral shows the rectangular cleavage, parallel extinction, high interference colors, uniaxial figure and negative character of scapolite. The cause of the dark color is seen in the presence of great quantities of small black inclusions. These are of irregular shape, often elongated parallel to the vertical axis of the scapolite. In some cases they are quite evenly distributed through the mineral, in others, are grouped in patches ; but nearly always a thin outer layer of the crystal is quite free from inclusions. Similar inclusions in scapolite are described by Rosenbusch * as consisting of carbonaceous matter and this is undoubtedly true of those under consideration. The same rock contains scapolite, usually in small grains, which contains no inclusions whatever. Titanite, pyroxene and mica are also abundant, the two latter sometimes intergrown.

Other varieties of the limestone are plenty, but as their interest is mineralogical rather than petrographic, their consideration is beyond the scope of this paper.

QUARTZITE.

The Potsdam sandstone, so far as examined under the microscope, possesses the character of a very pure quartzite. It is made up of well rounded grains of quartz, cemented into a tough, compact mass by the deposition of secondary silica. Besides quartz no mineral has been found forming complete grains, though other species are not uncommon as inclusions in the quartz. Of the minerals occurring in this way biotite zircon, apatite and rutile are the most abundant. Liquid inclusions are also present in great numbers, but never formed in the quartz subsequent to its incorporation into this rock.

When, as often happens, the rock is red, the color is due to finely divided hematite, which forms a thin coating over the quartz grains. The hematite clearly was deposited upon the quartz before the introduction of the cement, and its appearance suggests that it is the result of subaërial erosion, formed by some such process as that outlined by Russell. †

* Mikroskopische Physiographie, 3d edition, I., p. 363.

† Russell, I. C., The Subaerial Decay of Rocks, Bulletin 52, U. S. G. S.

In the white and gray varieties of the rock, a small quantity of argillaceous material coats the sand grains. The presence of this thin coating, particularly when it is hematite, gives to the outlines of the grains a clearness that they would otherwise lack. When, as is sometimes the case, the coating is absent it becomes difficult to draw any line between the grain and the surrounding cement.

The rock affords an excellent example of the secondary enlargement of quartz grains described by Sorby, * Irving † and others. About every sand grain quartz has been deposited until further growth was checked by contact with the quartz forming about adjacent grains. This secondary quartz always shows perfect optical continuity with the original quartz of the grain about which it is deposited. As a rule there is no opportunity for the development of crystal outlines, the process being too complete, but one or two faces are occasionally formed.

As a result of this process the rock is thoroughly indurated, being practically a solid mass of quartz.

PYROXENE ROCKS.

Near the base of the crystalline limestone, and seemingly interstratified with it, is a body of schistose, highly contorted rocks of somewhat doubtful character. In the field they were taken for metamorphosed sediments, and no particular attention was paid to them. But a microscopic study reveals a mineralogical composition that suggests the possibility of an igneous origin. Against such a supposition, however, strong evidence is afforded by the gradual transition often seen from limestone to pyroxene rock. While there is considerable diversity in the composition of different portions of these rocks, one variety is particularly abundant. It consists of feldspar, quartz, monoclinic pyroxene, mica, titanite, apatite, graphite, pyrrhotite, and pyrite.

Both orthoclase and plagioclase are present, sometimes one, sometimes the other predominating. In some sections they are very fresh, in others completely altered to muscovite and kaolin. Quartz is usually in small quantity or lacking. In a single section, where it is uncommonly abundant, it shows a serpentinous alteration along cracks, similar to that described and

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* Sorby, H. C., Proc. Geol. Soc. Lond., 1880, p. 62.

† Irving, R. D., Am. Jour. Science. III., XXV., p. 401. Bulletin 8, U. S. G. S., 5th Ann. Rep., U. S. G. S., p. 218.

figured by Becker.* The pyroxene is in irregular, often rounded masses, colorless or with a very faint greenish tinge, and extinction angle of about 40°. As a rule it is very fresh, though sometimes showing a slight greenish alteration along cracks. In one section considerable uralite has formed from it. The mica is rather light colored, but strongly pleochroic, and always very fresh. It increases in quantity as pyroxene decreases, producing phases of the rock that have nearly the composition of ordinary gneiss. Titanite is one of the most characteristic minerals of the rock, and is generally quite abundant. In no instance has it been found with crystal boundaries, but forms irregular masses, often quite large, and is distinctly pleochroic, changing from yellowish to brownish red. Graphite occurs in irregular scales, which are usually destroyed in the process of section grinding. In the micaceous variety of the rock, rutile appears in minute prismatic forms, very perfectly developed, and of a redish brown or blue color. The characteristic knee-formed twine is occasionally present.

While in the mass, the rock is prominently schistose, individual layers are often quite massive, and sections from these have granitic structure. Other sections show the constituents arranged in very distinct layers. Evidences of mountain-making action, such as undulatory extinction, bending of twinning lamellæ, and crushing of minerals, are abundant.

SCAPOLITE ROCKS.

One section of the pyroxene rock shows, instead of feldspar, some muscovite and a colorless mineral in small plates, with somewhat fibrous appearance, which proves to be scapolite. This specimen offords a connecting link between the pyroxene rocks and another rock rather closely resembling them. It shows under the microscope the same pyroxene, mica, titanite and pyrrhotite as irregular grains in a paste or ground mass of scapolite. This mineral is in large colorless plates, with distinct cleavage, which in basal sections shows cracks intersecting at right angles. Such sections are dark with crossed nicols and give an interference cross, from which the negative character of the mineral may be determined. Vertical sections yield brilliant interference colors.

The presence of scapolite in the section of pyroxene rock, seemingly in the place of feldspar, renders it probable that, as is so

* Becker, G. F., Geol. of Quicksilver Deposits of the Pacific Slope, p. 123.

often the case*, the scapolite is secondary after feldspar. But no section has yet been procured in which the process can be traced.

Lacroix† has described a rock occurring at Pierrepont, which from its character and association is evidently the equivalent of the rock under consideration, though differing from it in some respects. He also mentions several other localities in the State where the same rock occurs with crystalline limestone, the association of the two seeming to be quite common.

Somewhat similar rocks have been described by Becke‡ from lower Austria ; and there a transition is seen between the

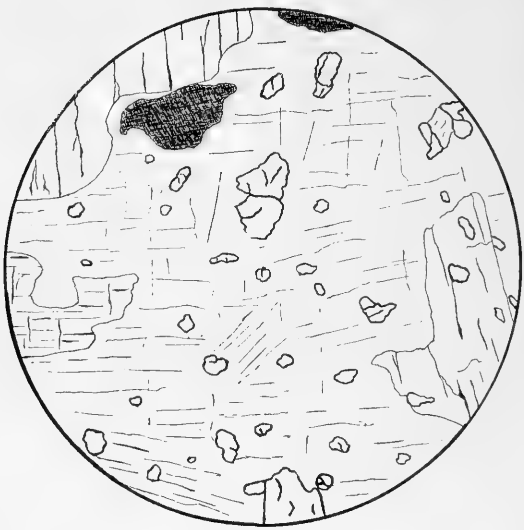

FIG. 2. Scapolite rock.
Pyroxene represented with light border.
Titanite " " dark "
Pyrrhotite shaded.
Scapolite, with irregular change, enclosing all other minerals.
Width of field, 2 min.

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* Lacroix, A., Sur. la transformation des feldspaths en dipyre, Bull. Soc. Min. Fr., XIV., p. 15. Judd, J. W., Mineralogical Magazine, VIII., p. 186.

† Lacroix, A., Thèses présentées a la Faculté des Sciences de Paris, 1re Contributions a l'Etude des Gneiss a Pyroxène et des Roches a Wernérite, p. 183.

‡ Becke, F., Die Gneiss formation des neiderösterreichischen. Waldviertel; Techermak's Mittheilungen, IV., p. 365, et seq.

pyroxene and scapolite rocks. However, they show some marked difference, both in composition and association, from the rocks at Gouverneur. The scapolite rock of the latter locality resembles more closely that from the Loire described by Lacroix.*

Another Gouverneur rock contains scapolite in much smaller quantity, together with titanite, pink pyroxene and abundant dark green hornblende. This rock occurs at three localities as sharply defined black bands in limestone. The mode of occurrence strongly supports the idea that these bands are dikes rather than interbedded layers. Unfortunately, the great amount of contortion in the rocks has so obscured their true relations as to render difficult a final decision upon this point.

In containing hornblende, the rock resembles the well known Norwegian scapolite rock†, as well as that of Canada‡, and of New Jersey.§ It is also similar to the latter in its association with crystalline limestone.

The possibility of the igneous origin of the Gouverneur scapolite rocks is thus suggested, not only by their composition and, in the case of some of them, their mode of occurrence, but also by their resemblance to other rocks whose igneous nature is very generally conceded. On the other hand, through the pyroxene rocks associated with limestone, they seem to be connected with metamorphosed sediments. A final decision as to their true character must be reserved until their field relations have been more thoroughly studied.

Hamilton College, Clinton, N. Y., April, 1893.

April 26, 1893.

Special Meeting.

Held in the evening, at the American Museum of Natural History, for the ceremonies attending the unveiling of the monument to John James Audubon in Trinity Cemetery, which was accomplished on the afternoon of the same day, by the Audubon Monument Committee.

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* Contributions a l'Étude des Gneiss a Pyroxène et des Roches a Wernérite, p. 1, et seq.

† A. Michel-Levey, Sur une roche à sphène, amphibole et wernérite granulitique des mines d'apatite de Bamle (Norwege) Bull. Soc. Min. Fr., I., p. 43.

‡ Adams, F. D., and Lawson, A. C., On Some Canadian Rocks Containing Scapolite. Canadian Record of Science, III., p. 185.

§ Nason, F. L., Ann. Rep. State Geologist of New Jersey, 1890, p. 32.

President BOLTON in the chair, and about four hundred persons present.

Mr. Morris K. JESUP, President of the Board of Trustees of the American Museum of Natural History, delivered an address of welcome to the Academy.

Professor Thomas EGLESTON, Chairman of the Audubon Monument Committee, gave an account of the inception and progress of the movement for the erection of a monument to Audubon.

President BOLTON read several unpublished letters of Audubon.

Mr. D. G. ELLIOT delivered an address entitled "The Life and Services of John James AUDUBON."

The report of the Audubon Monument Committee including addresses delivered at Trinity Cemetery and those delivered at this meeting will be presented to the Academy at a latter date and published in the Transactions.

May 1, 1893.

REGULAR BUSINESS MEETING.

President BOLTON in the chair and twenty-eight persons present.

Mr. Geo. H. KNIGHT, of New York City, was elected a Resident Member.

SECTION OF ASTRONOMY AND PHYSICS.

Prof. E. E. BARNARD, of the Lick Observatory, described some of his observations on the transparency of the "crape ring" of Saturn and the surface markings of Jupiter, Prof. BARNARD also showed some photographs of recent remarkable comets taken at the Lick Observatory.

May 8, 1893.

STATED MEETING.

President BOLTON in the chair, and thirty-two persons present.

The President called attention to the circular recently issued by the Smithsonian Institution relative to the Hodgkins Fund Prizes for treatises and essays on atmospheric air.

BIOLOGICAL SECTION.

The following papers were read :

"On a Recent Preparation of the Kidney of the Elephant," by Prof. G. S. HUNTINGTON.

ON RECENTLY DISCOVERED DEPOSITS OF DIATOMACEOUS EARTH IN THE ADIRONDACKS.

BY CHARLES F. COX.

The construction of the new railroad (The Mohawk and Malone) in the Adirondack Mountains during the past year has led to the recognition, and, in some cases, the actual discovery, of extensive deposits of diatomaceous earth previously unknown to science. The deposits referred to, occur principally upon the bottoms of four small lakes, one of which is in the extreme southern part of Herkimer county, near the town of Hinckley, and the other three in the extreme northern part of the same county in Township No. 43. There are evidences of smaller deposits in the intervening country, particularly in certain railroad cuttings, and, perhaps, in bogs and sink-holes which have been the cause of trouble in the construction of the road. The deposit near Hinckley has been known to the inhabitants of this region for a long time, and the pond in which it occurs has been called by them White Lead Lake. But specimens of this earth do not seem to have reached naturalists until very lately. The deposits in Township No. 43 appear to have been entirely unknown until the Mohawk and Malone Railroad was constructed. They occur in Clear Lake, Roilly Pond, and in an apparently unnamed body of water near Big Crooked Lake. The deposits in sight at Hinckley has been estimated at 100,000 cubic yards ; that at Clear Lake at about the same amount ;

while those at Roilly Pond and Big Crooked Lake have been estimated at more than a million cubic yards each.

The character of the Hinckley earth, as disclosed by the microscope, and probably that of all the other earths referred to, is not materially different from that of a hundred deposits found throughout the glacial region of New England, excepting that this Herkimer county earth appears to be much purer than any other known diatomaceous deposit, both in the number of unbroken forms found in it, and in its freedom from sand and other foreign material. Identifications have been made of eleven genera and about forty species of Diatomaceæ, of which more than thirty species are of the genera *Navicula*, *Stauroneis*, *Cymbella* and *Eunotia*, which are almost always prominent in the lacustrine deposits of our northern States. These are all solitary and motile forms, indicative of a still water habitat, as distinguished from those filamentous forms like *Melosira*, which are characteristic of running water, and those sessile forms like *Coscinodiscus* and *Arachnoidiscus*, which are characteristic of the seashore.

The discovery of these Herkimer county deposits has its main value in the relation which it establishes between the glacial lake region of the Adirondacks and similar geological formations in other parts of the country. A careful comparison of all diatomaceous deposits on this continent would lead to results of considerable importance, and this is a field of research which has been heretofore generally neglected.

May 15, 1893.

STATED MEETING.

President BOLTON in the chair, and sixty persons present.

Dr. Edward G. LOVE delivered the eighth lecture of the Public Lecture Course, 1892–1893, on "Photographing Microscopic Objects," illustrated by lantern slides, apparatus and photographs.

May 22, 1893.

Prof. R. P. Whitfield in the chair, and thirty persons present

SECTION OF GEOLOGY AND MINERALOGY.

The following papers were read :

"The Granite at Mounts Adam and Eve, Orange County, N. Y., and its Contact Phenomena," illustrated by maps, photographs and specimens. By James F. Kemp and Arthur Hollick.

It described the general geology of the region, reviewed the literature, which, however, is meagre, nothing having been written since Mather's Report of the New York State Survey in 1844, and commented on the results obtained in New Jersey. The petrography of the granite, and of the blue and white limestones was described, as were the interesting minerals of the contact zones along the borders of the granite and the white limestone. The conclusions reached, were that the white limestone had suffered extensive contact metamorphism from the granite intrusions ; but as to whether the white limestone is altered blue or not the evidence is less conclusive. The authors believed, however, from the field relations, the transition forms and the commingling of the two, that the white was metamorphosed blue.

Some notes on Helderberg fossils found near Stone Bridge concluded the paper.

The contribution was discused by Professor A. H. Chester, especially as regards the mineralogy of the contact zones, and the close parallel that they offer to those of the New Jersey limestones.

Dr. N. L. Britton spoke of his work in New Jersey and the apparent interstratification of the white limestone with the gneisses, and the opposing dips of the blue and white that led him to conclude that they were of different ages.

Remarks were also made by Prof. R. P. Whitfield.

The paper will be published in the Annals.

PRELIMINARY CONTRIBUTION TO OUR KNOWLEDGE OF THE CRETACEOUS FORMATION ON LONG ISLAND AND EASTWARD.

[Plates V—VII.]

BY ARTHUR HOLLICK.

The assumption that cretaceous strata were to be found beneath a part of Staten Island and practically the whole of Long Island, except the small archæan area at its western end, has been recognized as probable by nearly every geologist who has studied the region. The trend of the cretaceous strata in New Jersey and their stratigraphic relations to the crystalline and other rocks along their border, justified the assumption that the same conditions prevailed northeastward, although there much modified by the forces which acted upon them during the quaternary age. The lithological characters were also such that the similarity of the clays and sands of New Jersey, Staten Island and Long Island, was early recognized. So that stratigraphically and lithologically the assumption seemed justified. Palæontologically, however, until within the past ten years or so, the indications were very meagre and unsatisfactory, and it has only been within that time that we can be said to have collected sufficient evidence to justify the positive declaration that the early assumption was correct. In regard to Staten Island the facts have already been published*. The facts relating to Long Island have been briefly mentioned on several occasions, notably at meetings of the Academy, and memoranda have appeared in print, but nowhere has any connected account been published. The object of this contribution is to present all the facts thus far known to the writer. New material is constantly coming to light, but it has been decided to describe in advance some that is now available, in order to demonstrate the existence of cretaceous strata on Long Island beyond any further doubt, and thus to correct an erroneous impression which seems to be

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* "Palæontology of the Cretaceous Formation on Staten Island." (Trans. N. Y. Acad. Sci. XI. 96-103) and "Additions to the Palæobotany of the Cretaceous Formation on Staten Island." (Trans. N. Y. Acad. Sci. XII. 1-12.) 1892.

entertained in certain quarters, that the evidence is still incomplete*.

Before describing the later discoveries, however, it has been thought advisable to give the following brief review of the observations which preceded them:

The earliest attempt at a differentiation of the later formations in the eastern United States, upon anything like a modern basis, was made about 1825, and may be said to have begun with the studies of Lardner Vanuxem and S. G. Morton. The latter, in a paper read before the Philadelphia Academy of Natural Sciences†, divides the coast plain into Secondary, Tertiary and Alluvial, and speaks of Manhattan and Long Islands, Martha's Vineyard and Nantucket as being included within the Tertiary (the equivalent of the tertiary as we recognize it to-day). They were also the first to note the equivalence of the New Jersey strata with the cretaceous of the old world—a conclusion which was arrived at by the study and comparison of the fossil faunas.

In 1841, Sir Chas. Lyell visited this country, and in his subsequent contributions‡ he describes his visit to New Jersey and acknowledges the correctness of Morton's conclusions in comparing certain of the strata there with the European cretaceous. These papers, incomplete as they appear to us now, marked an epoch in our knowledge of the formations in question. The previous observations and speculations in regard to the age and structure of the strata composing the eastern border of our continent were exceedingly crude and chaotic, such as those of Samuel L. Mitchill§, in the early years of the present century, from which I had occasion to quote in a former paper||, and the same author subsequently furthur discusses the geology of the north shore of Long Island, in a communication to Archibald

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* Bull. No, 82, U. S. G. S. Correlation Papers—Cretaceous. C. A. White. 1891.

p. 85. "Several persons have written upon, or referred to, the discovery of cretaceous fossils upon Long Island; but a large proportion of these reported discoveries lack confirmation. Beyond the identification by Prof. Newberry of a few species of fossil plants which have been obtained at different localities along and near the north shore of the western portion of the island, the evidence of the existence of cretaceous deposits there is mostly or entirely confined to the known or assumed trend of the cretaceous outcrop which has just been mentioned, and to lithological similarity of certain deposits there to those of portions of the non-marine division of the New Jersey cretaceous section."

† "Geological Observations on the Secondary, Tertiary and Alluvial Formations of the Atlantic Coast of the United States of America." (Journ. Acad. Nat. Sci. Phil. vi. Part i. 59-71 (1827).)

‡ "Notes on the Cretaceous Strata of New Jersey and Other Parts of the United States bordering the Atlantic." (Am. Journ. Sci. xlvii. 213-214 (1844) and Quart. Journ. Geol. Soc. London, i. 55-60 (1845).)

§ Med. Repos. iii. 2d Ed. 325-335 and v. 212-215 (1805, 1802).

|| Trans. N. Y. Acad. Sci. xii. 189-202 (1893).

Bruce, dated July 4, 1811*, in which he criticises, William Maclure's geological map of the United States† in so far as it relates to this region, and amends his former conclusions in regard to the "primitive" character of the rocks, regarding them all as "alluvial," except "the strata of granite and gneiss which occur at and near Hurlgate." He is largely led to these later conclusions by the discovery of clam, oyster and periwinkle shells and "carbonated wood" many feet below the surface in Brooklyn, New Utrecht, Flatbush, Newtown and Bushwick, in or below the Drift as we know it to-day. He continues: "I say nothing of the *wood* discovered sixty feet deep, a little to the eastward of Westbury Meeting-house; nor of *the bark, and other parts of a tree,* raised from the depth of forty feet at Eastwoods; because both these places are situated to the south of the barrier ridge, and are within the district allowed by all to be alluvial."

On July 15, 1823, John Finch read a paper before the Academy of Natural Sciences of Philadelphia, entitled "Geological Essay on the Tertiary Formation in America"‡, in which he refers the Staten Island, Long Island, Raritan and Gay Head clays to the tertiary.

Shortly after this followed the researches of Vanuxem and Morton, previously mentioned, which really mark the beginning of our modern conceptions of the true relationships of the strata.

In 1837 and 1838, in the first reports of the geological survey of New York§, mention is made of the clays and sands on Staten and Long Islands, but with only vague allusions to their probable geological relations—the deposit on Staten Island being supposed to be "similar in its general character to that of Cheesequake and Matavan Point, on the New Jersey shore, and it appears to have a similar geological position," while in regard to Long Island the contorted condition of the clay strata and the large amount of lignite contained in them are mentioned, and also that "they have the external characters of potters' clay," but they also are referred to the tertiary.

In the final report, published in 1843||, Mr. Mather arrives at

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* Am. Min. Journ. i. 129-133 (1814).

† Trans. Am. Phil. Soc. vi. 411-428 (1809).

‡ Am. Journ. Sci. vii. 31-43 (1824).

§ Assembly Document No. 161. Communication from the Governor [W. L. Marcy] relative to the geological survey of the State. First Ann. Rept. 1st Geol. Dist. Wm. M. Mather (Feb. 11, 1837), and Assembly Document No. 200, Second Rept. etc. (Feb. 20, 1838).

|| Nat. Hist. N. Y. Part iv. Geology, Part i. comprising the Geology of the First Geological District.

more definite conclusions in regard to the same strata, and under the heading "Upper Secondary System, I., Long Island Division," says: "The reasons for believing that the principal mass of this formation is older than the Tertiary will be seen in tracing the equivalency of these beds to those of New Jersey, Maryland, Delaware and Virginia, where it is considered as established that the corresponding strata belong to the upper secondary of the epoch of the cretaceous and greensand formations." So that stratigraphically and lithologically the true relationship between Long Island and the rest of the Atlantic coastal plain was beginning to be appreciated. Tertiary and later fossils had been found on the island, but the palæontological evidence of its cretaceous strata was wanting. About this time a discovery was reported which caused considerable discussion, the echoes of which have been heard to within a few years ago. At the meeting of the New York Lyceum of Natural History on December 19, 1842, a specimen of *Exogyra* was shown, said to have been found in digging a well in Brooklyn. I quote as follows from the minutes of that meeting: "Dr. Jay exhibited a fossil Exogyra, found sixty feet below the surface, in digging a well in the city of Brooklyn. Referred to Messrs. Jay and W. C. Redfield to report upon the authenticity of the locality and other matters respecting the geological relations of the fossil." In the minutes of the meeting of January 9, 1843, the report of this committee is included, from which the following facts are abstracted: The fossil was found in 1834 by ——— and Newman, well-diggers, while excavating a well in Clark street, between Willow and Pineapple streets. It was taken by them to Mr. Smith, late Mayor of Brooklyn, who descended the well and examined personally the location where it was found, about sixty-five feet below the surface. The shell was said to have contained "a dark colored earth or residuum, differing from the earth in which the fossil was imbedded."

The discovery was again mentioned at the Albany meeting of the Association of American Geologists and Naturalists in 1843, by Mr. Redfield, who said: "This is believed to be the first authentic memorial of the cretaceous formation found in the State of New York."* It is also mentioned by Issachar Cozzens, Jr., who evidently considered it as significant, and who prophesies as follows:"† "It is more than probable that this mem-

* Abstract of the proceedings, 4th session. Assn. Am. Geol. & Nat. in Am. Journ. Sci. xlv. 135-165 (1843).

† "Geological History of Manhattan or New York Island," etc., pp. 114 (1843).

ber of the Cretaceous Group [New Jersey Marl] underlies Long Island, and may be a continuation of the great range which begins at the south, in Virginia, and runs through New Jersey to the Neversink Hills, at which place it is last seen above the surface."

This same *Exogyra* is also quoted by several subsequent writers, long after it had lost its importance as an indication of the presence of cretaceous strata, by reason of the discovery of other indisputable cretaceous material *in situ*. The latest reference is by C. A. White*, who, following the early conclusions of E. D. Cope†, had divided the eastern cretaceous strata into "marine" and "non-marine." He says: "All the admissible evidence of the present existence of cretaceous deposits upon Long Island relates to the non-marine division alone. If the reputed discovery of a specimen of *Exogyra costata*, Say, in digging a well near Brooklyn were satisfactorily confirmed, and it were shown to have been found *in situ*, the fact would be accepted as proof of the present existence there of at least a portion of the marine division."

The probable extension eastward and northward of the strata composing the coastal plain was noted by Edward Hitchcock in 1824, in a paper entitled "Notices on the Geology of Martha's Vineyard and the Elizabeth Islands"‡, where he says:

"Long Island, in those places where I have seen it, is unquestionably very similar in its geological structure to Martha's Vineyard, and probably belongs to the same era. . . If we take [Maclure's] map, and prolong the line, or rather curve, that separates the alluvial tract . . from the primitive towards the northeast, we shall find that it passes between Martha's Vineyard and the continent . . leaving us to conclude that the Vineyard and Nantucket are the continuation of that extensive formation, hitherto called Alluvial, of which Long Island has been regarded the northeastern limit."

Subsequently, the same author notes the occurrence near Marshfield, Mass., of material similar to the greensand or marl of New Jersey§, and also suggests the probable cretaceous age of certain of the strata on Martha's Vineyard||. In this connection should be mentioned the first discovery and description of

* Bull. No. 82, U. S. Geol. Surv. Correlation Papers—Cretaceous. (1891.)

† Proc. Acad. Nat. Sci. Phil. xx. 157, 158 (1868).

‡ Am. Journ. Sci. vii. 240-248 (1824).

§ Rept. on the Geol. of Mass., examined under the direction of the Government of that State during the years 1830 and 1831 (Am. Journ. Sci. xxii. 1-70 (1832).

|| Final Rept. on the Geol. of Mass., vol. ii. pp. 429, 430, Pl. 19, figs. 1-5. (1841.)

fossil leaves and fruit from these strata—a discovery the importance of which we can only appreciate fully in the light of investigations made within the past few years, inasmuch as some of these can now be identified with well-recognized cretaceous species subsequently found in New Jersey, Staten Island, Long Island and Martha's Vineyard itself. Prominent among Prof. Hitchcock's specimens from the latter locality are certain "pear-shaped seeds," in regard to which he says: "It seems to me very obvious that these remains must be the seed vessels of coniferous plants"—an observation which shows a very acute appreciation of their probable affinities, as the same objects have been found abundantly throughout the localities mentioned and have been considered as *Dammara* or possibly *Eucalyptus* by more recent investigators, as will be noticed more fully further on.

In 1849, there appeared an article by M. E. Desor and E. C. Cabot, "On the Tertiary and more recent Deposits in the Island of Nantucket,"* in which they refer to the resemblance between the clay at Sankaty, Nantucket, Truro on Cape Cod and Gay Head, Martha's Vineyard, which are all referred to as probably Tertiary and the conclusion is reached that "Thus the Tertiary cliffs of Gay Head should no longer be looked upon as an isolated fact, but the cliffs of Sancati may be considered as the opposite outcrop of a large tertiary basin, underlying the islands of Nantucket and Martha's Vineyard . . and extending to the south below Long Island and to the north as far as Truro."

In August, 1859, William Stimpson visited Martha's Vineyard and confirmed Prof. Hitchcock's conclusion in regard to the cretaceous age of certain of the strata†, having collected both animal and vegetable remains. The notice in regard to this excursion is, however, very meagre.

At the meeting of the Philadelphia Academy of Natural Sciences on June 2, 1868, E. D. Cope gave an account of his discovery of the fresh-water origin of sands and clays in west New Jersey, on the Delaware River above Camden, which he found to contain leaves of dicotyledonous trees, ctenoid fish scales and numerous unionidæ‡.

The prosecution of the New Jersey Geological Survey, under Geo. H. Cook, from 1865 to 1887, with its various reports and maps, gave not only exact descriptions of the cretaceous strata

* Quart. Journ. Geol. Soc. London, v. 340-344 (1849).

† "Cretaceous Strata at Gay Head, Mass." (Am. Journ. Sci. xxix, 145 (1860).

‡ Proc. Acad. Nat. Sci. Phil. xx. 157-158 (1868).

in New Jersey, but reference to their probable extension through Staten Island and Long Island.

In 1873, a geological map of the United States, prepared by C. H. Hitchcock and W. P. Blake, was published in connection with the Ninth United States Census, On it the north shore of Long Island is shown as cretaceous, in accordance with the views of nearly all who had studied the region. It was criticised, however, by J. D. Dana*, whose ideas in regard to the geology of Long Island have frequently differed from those held by most other authorities, and he advised, as an improvement, "to take away the green color, which means cretaceous, from the whole of the north side of Long Island, no facts making the region cretaceous.'' Prof. Hitchcock replied briefly to this criticism and gave his reasons for coloring the map to represent cretaceous, in a paper read at the Portland, Me., meeting of the American Association for the Advancement of Science in 1873†, in which he says, ''Notwithstanding the evidence is so probable in its favor, it is surprising to observe that mine is the first published map that colors their area correctly.''

Professor Dana subsequently modified his criticism‡ by referring to the conclusions of Wm. M. Mather, previously quoted, and ending with the brief paragraph, "We understand that there are recent discoveries which will place Prof. Mather's conclusion on a better foundation." This practically ended any further controversy in regard to the age of the Long Island strata, for evidence of the presence of cretaceous strata along the north shore of the Island began to accumulate and could no longer be ignored. At a meeting of the New York Lyceum of Natural History, January 9, 1871, attention had been called to angiospermous leaf impressions found in a drift bowlder while digging a well at Williamsburg (Brooklyn), Long Island§, and at the meeting of the same society on March 23, 1874, similar specimens were shown from Lloyd's Neck||, many miles further to the eastward on the north shore of the island. Specimens containing dicotyledonous leaves also turned up in other parts of Brooklyn during excavations for various purposes, and some of these fortunately came into the possession of the Long Island Historical Society, thus insuring their preservation, with the facts connected with their discovery.

* Am. Journ. Sci. vi. 64-66 (1873).

† Proc. A. A. A. S. xxii. Part 2d, 131-132 (1874).

‡ Am. Journ. Sci. vi. 305 (1873).

§ Proc. Lyc. Nat. Hist., 1st Ser., 149, 150 (1871).

|| Proc. Lyc. Nat. Hist., 2d Ser., 127 (1874).

The character of the rock was not understood at the time, however, and it was not until a few years subsequently, when specimens were found *in situ*, in connection with the clays at Glen Cove, a locality between the other two, that their derivation was understood.

On April 4, 1881, N. L. Britton read a paper before the Academy "On the Geology of Richmond County, N. Y.,"* in which the probable eastward extension of the cretaceous strata through Staten and Long Island is mentioned, and on November 7, 1884, Fredk. J. H. Merrill read a paper before the Academy on the geology of Long Island†, in which he maintains a very conservative attitude in regard to the cretaceous formation. The *Exogyra* previously mentioned is referred to, and also the leaf-bearing sandstone, but the evidence is considered as too incomplete, and he merely concludes that "The locality at which the strata most resemble the cretaceous beds of New Jersey is at Glen Cove, where the clays already described are probably of this age."

Just previous to this time J. S. Newberry began his studies of the Amboy clay flora, and shortly afterwards, his views were briefly presented before the New York Academy of Sciences‡ and the Torrey Botanical Club§. Dr. Newberry was the first to correlate these clays with the Dakota group of the west and the Lower Atane beds of Greenland, by means of their fossil floras, and his researches in this direction also enabled him to at once identify the fossil leaves collected about the same time at Glen Cove as identical with those from the Amboy clays, and thus to fix without question the cretaceous age of the strata, and similar further work in the same direction was subsequently performed by R. P. Whitfield for the fauna||.

At a meeting of the New York Academy of Sciences, on May 11, 1885, Fredk. J. H. Merrill gave a description of the beds at Gay Head, Martha's Vineyard, and referred them to the post pliocene or quaternary.¶

In 1888, a report upon the geology of Martha's Vineyard** appeared, by N. S. Shaler, and in the following year one upon

* Ann. N. Y. Acad. Sci. ii. 161-182 (1882).

† Ann. N. Y. Acad. Sci. iii. 341-364 (1885).

‡ Trans. N. Y. Acad. Sci. v. 133-137 (1886).

§ Bull. Torr. Bot. Club, xiii. 33-37 (1886).

|| Bull. Am. Mus. Nat. His. ii. Art. viii. 113-116 (1889).

¶ Trans. N. Y. Acad. Sci. iv. 78, 79 (1885).

** 7th Ann. Rept. U. S. G. S. 297-363 (1888).

Nantucket*. Cretaceous and tertiary deposits are recognized upon the former, by means of the fossils, but only tertiary and later on the latter. The author also discusses at some length the stratigraphy of each island and the probable changes which have preceded their present condition.

In 1889, Prof. Shaler published a paper "On the Occurrence of Fossils of the Cretaceous Age on the Island of Martha's Vineyard, Mass.,"† in which he discusses the probable origin of the fossils and the dislocation of the beds. The fauna only is described, no flora.

In 1889, David White visited Gardiner's Island, Block Island, Center Island and Martha's Vineyard, and collected a large amount of cretaceous material, especially plants‡, which I was kindly permitted to examine during the past winter, and was thus enabled to idenitfy a large number of the species with those which I had previously collected on Long Island and had become familiar with from the cretaceous of Staten Island and New Jersey. These discoveries proved to be of the highest importance, as we were thus enabled to trace the continuity of the cretaceous strata from New Jersey through Staten and Long Islands to Martha's Vineyard, and to demonstrate beyond question that the theory of Mather and subsequent observers in regard to the eastward extension of the cretaceous formation was correct, and that the geological maps of the region should not only show the north shore of Long Island, but also part of Martha's Vineyard as cretaceous§, and emphasized the probability that certain limited areas of the New England coast could also be referred to that horizon.

The Long Island material upon which this paper is based consists entirely of fossil plants, no animal remains which could be even provisionally referred to the cretaceous having come under my observation. Fortunately, however, many of these plant remains are in such a perfect state of preservation that they may be readily identified with well known cretaceous species, and the age of the strata in which they occur or from which they have been derived can no longer be questioned.

The total number of species represented in the specimens

* Bull. No. 53, U. S. G. S. (1889).

† Bull. Mus. Comp. Zoöl. xvi. No. 5, 89-97 (1889).

‡ Am. Journ. Sci. xxxix. 93-101 (1890), and Bull. Geol. Soc. Am. i. 554, 555 (1890), with comments by Lester F. Ward, J. S. Newberry and F. J. H. Merrill.

§ The two most recently published geological maps of the United States are 1st, by W. J. McGee, in 5th Ann. Rept. U. S. G. S. (1884), and, 2d, by C. H. Hitchcock, for the Am. Inst. Mining Eng. (1886). In each of these the north shore of Long Island is recognized as cretaceous, but Martha's Vineyard is designated as tertiary and quaternary only.

which I have collected or have been enabled to examine is about forty. Of these, some are too fragmentary for exact determination, others, require further examination and comparison, and the remainder are such as have been identified satisfactorily with previously described cretaceous species. These latter are the only ones which it is proposed to include in this contribution.

The greater portion of the material was personally collected on or near the shore of Hempsted Harbor, at Glen Cove. The late Dr. John I. Northrop and other collectors also found specimens at the same locality and on the near-by Dosoris island. A few came from Lloyd's Neck and Brooklyn, and the remainder from Northport and Cold Spring Harbor. All, with the exception of a few in the possession of the Long Island Historical Society are now in the geological museum of Columbia College. The specimens from Glen Cove, Northport and Cold Spring Harbor were found in the clays or else intimately associated with them. All the others were found in the drift, in ferruginous clay concretions or sandstones, exactly as I had previously found them to occur in parts of the drift on Staten Island*. These concretions and blocks of sandstone may be found everywhere in the drift to the south of former cretaceous areas. They represent fragments of cretaceous clays and sands which have been torn up by the continental glacier and carried forward in the *débris* of the moraine, where they have become hardened by the infiltration and oxidation of ferruginous matter or by the accumulation of limonite on the outside. They are so abundant in the drift, wherever this has crossed any cretaceous outcrop, that they must have been known for a long time, but they failed to attract attention until it was noticed that they occasionally contained impressions of leaves and stems of plants, when their derivation became an interesting problem. No such rock as that in which they were found was known to the north of the moraine, and when it began to be appreciated that the leaves contained in them were of dicotyledonous plants the problem became of still greater interest. Dr. Newberry was one of the first to recognize their importance.

In the Proc. N. Y. Lyc. Nat. Hist. 1st Ser. pp. 149, 150, in the account of the meeting of January 9, 1871, the following paragraph occurs :

The President, Dr. J. S. Newberry, exhibited a piece of red sandstone, containing impressions of leaves, found in excavating the foundation for the gas office in Williamsburgh [Long Island]. This, he said,

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* "Palæontology of the Cretaceous Formation on Staten Island." (Trans. N. Y. Acad. Sci. xi. 96-103.)

was a specimen of remarkable interest. In its lithological characters this rock closely resembles the Triassic sandstone so much used in New York for architectural purposes, but *it contained numbers of very beautifully preserved impressions of angiospermous leaves.* No plants of this kind were known to exist during the Trias, or before the Cretaceous; but we know of no such Cretaceous or Tertiary sandstone on the North American Continent. The mass from which this specimen was taken was a bowlder and the associated transported blocks were granite, porphyry, greenstone, dolomite, etc., plainly refererable to well-known localities north of New York. But no such sandstone as this was known, and it became a matter of extreme interest to ascertain what was its origin.

Again, at the meeting of March 23, 1874, as reported in the Proceedings, 2d Ser. No. 4, pp. 126, 127, the matter came up in the following form:

The President described a sandstone containing angiospermous leaves very similar in aspect to those of the Raritan and of the Lower Cretaceous in the far west, which occurs in bowlders at Lloyd's Neck, L. I. This is undoubtedly the same rock with that of the Williamsburgh Gas House, as he was satisfied by comparison. It is totally unlike anything known in this vicinity, and unfortunately, has not yet been found *in situ.* Whenever it is, some interesting light will be thrown on the whole question. But its presence under these circumstances, points to its existence in place, at some locality not far away.

As previously stated, we have since found it in place at Glen Cove, and can account for other masses on the theory of glacial transportation and subsequent hardening of incoherent cretaceous material. The demonstration of these facts, however, came too late for their appreciation by Dr. Newberry. Our present interpretation of the facts is also of importance, as indicating the former existence of cretaceous strata in localities where their presence was not suspected, or if suspected, could not be demonstrated. By means of similar facts I was first able to trace the extent and positive existence of the cretaceous formation on certain parts of Staten Island, and reasoning from similar premises and facts in Long Island, we must conclude that at least a portion of New York Harbor and the East River to the north of Brooklyn was occupied by cretaceous strata. It is probable that the archæan axis, which extends through Staten Island and thence diagonally across the harbor to New York, with extensions up the river valleys, was the old shore line in this vicinity, as we find it to have been the case elsewhere. Further eastward, there seems to be no question that cretaceous strata occupied practically the whole of what is now Long Island Sound, as I have discussed in a previous article.*

At the western end of Long Island, where Brooklyn now is, the extent of cretaceous strata subject to erosion by the glaciers was very limited, and the paucity of such indications need not surprise us. In fact, the discovery of the few fossil leaves which have been made in digging wells and sewers there, may be considered peculiarly fortuitious. While examining the moraine through the Eastern district of Brooklyn, I was particularly impressed with the great number of the characteristic concretions, many of them containing plant remains (lignite and twigs)at the headof the Newtown Creek valley. I can only account for this as due to the material which was eroded in the formation of the valley. Such valleys or inlets are among the most prominent features in the topography of the north shore of the island, and ice action has been advocated by previous observers as their probable cause. Having this theory in mind, the fact above noted is of some significance.

At this part of the island the clays do not appear anywhere in mass, so far as I am imformed. They were probably in such limited amount on the north side, where subjected to glacial action, that they were entirely eroded, while to the south they were deeply covered by the moraine. As we proceed eastward, however, we find the clays out-cropping on the north shore at many localities, though generally much squeezed and contorted by the pressure of the ice sheet, and they are invariably met with on the south side, containing lignite, whenever wells or other excavations have been sunk to a sufficient depth. Throughout the moraine, also, wherever I have examined it, the characteristic concretions and micaceous sandstones are abundant.

Only a beginning has yet been made in the search for plant remains, but now that attention has been called to the matter they are being reported from a number of localities, and specimens are constantly coming to light, and there seems to be no doubt that the entire north shore of the island will present the same story to the searcher, when it has been carefully explored.

In the vicinity of Glen Cove, where the greatest amount of exploration has been personally made, the clays are exposed at the base of steep bluffs fronting the shores. At Carpenter's clay pits, on the west shore of the cove, a fine white clay is found, associated with sandy clay, white sand, gravel and "kaolin"; all of which are mined for economic purposes. A few

* Trans. N. Y. Acad. Sci. xii. 190-202.

leaf fragments have been found in the clays, occurring precisely as they may be found in the clays of New Jersey. On the opposite side, and along the shore of the Sound vari-colored clays are to be seen outcropping on the shore and at the base of the bluff. At a point about midway between the mouth of the cove and Glen Cove landing is a stratum containing lignite, pyrite, and a quantity of red ferruginous shale, in which latter the leaf impressions are well preserved. This stratum is uncovered at low tide, and may be traced into the adjoining bluff. The red shale may be here seen in place and be readily obtained. The tides constantly wear away the clay, exposing the shale, and this is torn out by the waves and scattered along the beach. The first specimens were found in this manner, merely as loose fragments on the beach, and it was not until about a year ago that they were traced to their original situation in the clay outcrop.

Following is the list of cretaceous species thus far identified :

MAGNOLIA CAPELLINI, Heer.

Pl. VI. f. 6.

This specimen is referred to the species described and figured by Prof. Heer in Phyllites Crétacées du Nebraska, T. III. f. 5, 6, and Flor. Foss. Arct. III. T. XXXIII. f. 1-4. In the original description of the Nebraska leaf, the base of the leaf is described and figured as obtuse, which characteristic does not seem to be insisted upon in the specimens subsequently identified by the author with the same species from the L. Atane beds of Greenland. With the latter, our specimen is plainly identical.

Locality : Glen Cove, L. I.

MAGNOLIA SPECIOSA, Heer.

Pl. VII. f. 4.

In the Kreide-Flora von Moletein, on Pl. VI., VII. and IX.' Prof. Heer figures under this name certain species which so closely resemble the one here figured, that if we are to retain it in the genus *Magnolia* no separation would seem advisable. I have thought that its affinities might be with *Laurus*, (See *L. proteæfolia*, Lesq. Cret. and Tert. Flor. VIII. 52, 53, Pl. III. f. 9, 10 and XVI. f. 6), or with certain forms described under *Ficus*, (*F. Krausiana*, Heer, Kreide-Flora von Moletein, 15, Pl. V. f. 3-6), but its general appearance and associations seem to be more in favor of the name here adopted. I am not aware that either of the above species have yet been identified from the New Jersey clays, but the indications are that they are not uncommon on Long Island.

Locality: Glen Cove, L. I.

LIRIODENDRON SIMPLEX, Newb.

Pl. V. f. 1-5 and Pl. VII. f. 2, 3.

Under this specific name I have included a variety of forms referable to the one genus. Dr. J. S. Newberry, in his first description of the species, (Ancestors of the Tulip Tree, Bull. Torr. Bot. Club, XIV. 1-7, Pl. LXI., LXII.), called attention to the great variation in this and allied forms (*L. primaevum*, Newb.; *L. semi-alatum*, Lesq.; *L. Meekii*, Heer; *Sapotacites retusus*, Heer; *S. Haydeni*, Heer; *Leguminosites Marcouanus*, Heer; *Phyllites obcordatus*, Heer, etc.). Subsequently, in the manuscript of the Flora of the Amboy Clays, he decided that the forms originally described by him, under the name *Liriodendron simplex*, were generically distinct from *Liriodendron*, and a new genus, *Liriodendropsis*, was founded, to include them. The species was also split into two groups, the broad forms being called *L. simplex*, and the narrower ones *L. angustifolius*. These latter are represented, in our specimens, by f. 3, Pl. V. Similar forms were also figured by me from Staten Island. (Palæontology of the Cretaceous Formation in Staten Island, Trans. N. Y. Acad. Sci. XI. Pl. II. f. 3 and 6.) The broad forms are by far the commonest, and are indeed the most abundant of all the cretaceous leaves thus far found either on Staten Island or Long Island, and are likewise so reported by Mr. David White from Gay Head, Martha's Vineyard. (Cret. Plants from Martha's Vineyard, Am. Journ. Sci. XXXIX. (1890) 93-101, Pl. II.) Intermediate forms are figured on Pl. V. f. 5 and Pl. VII. f. 3. Until such time as the Flora of the Amboy Clays is published, I have thought it best to retain Dr. Newberry's only published name for these leaves.

All the specimens here figured are from Glen Cove, L. I.

SAPINDUS MORRISONI, Lesq.

Pl. VI. f. 3.

Reported, also, from Staten Island and Martha's Vineyard.

Locality: Glen Cove, L. I.

DALBERGIA RINKIANA, Heer.

Pl. VI. f. 4, 5.

The specimens here figured seem to agree closely with those described and figured by Prof. Heer, under the above name in Flor. Foss. Arct. VI. 102, Pl. XXVI. f. 1-3. Our specimens vary considerably in size, and it is possible that we may have more than one species represented. I do not know that it has been previously reported from the eastern United States.

Locality: F. 4. from Williamsburg (Brooklyn), L. I.; f. 5 from Lloyd's Neck, L. I.

DIOSPYROS PRIMÆVA, Heer.

Pl. VII. f. 5.

Previously reported from New Jersey and Staten Island.

Locality: Glen Cove, L. I.

LAURUS PLUTONIA, Heer.

Pl. VI. f. 1.

This species has been identified previously from both New Jersey and Staten Island.

Locality: Glen Cove, L. I.

SASSAFRAS (ARALIOPSIS) ACUTILOBUM, Lesq.

Pl. VII. f. 1.

This exceedingly variable species, first described and figured by Prof. Lesquereux (Cret. Flor. VI. 79, Pl. XIV. f. 1, 2,) is well represented in its average shape and size by the specimen here figured. In the Amboy clays it is very abundant, but only this one specimen has as yet turned up on Long Island.

Locality: Glen Cove, L. I.

MYRTOPHYLLUM (EUCALYPTUS?) GEINITZI, Heer.

Pl. VI. f. 2.

Previously reported from New Jersey, Staten Island and Martha's Vineyard.

Locality: Glen Cove, L. I.

MAPS, ETC., USED.

Geological Map of the United States, published in connection with the 9th U. S. Census, by C. H. Hitchcock and E. P. Blake.

Geological Map of New Jersey. Rept. Geol. Surv. of N. J., 1882.

Geological Map of the Vicinity of New York, by D. S. Martin.

Coast Survey Chart No. VIII. Approaches to New York. Gay Head to Cape Henlopen.

The Ancestors of the Tulip Tree (Plates LXI. and LXII. Bull. Torr. Bot. Club, Jan. 1887) by J. S. Newberry.

Flora Fossilis Arctica, Vols. VI. and VII. (Plates representing the fossil flora of the L. Atane and Patoot beds), by Oswald Heer.

United States Geological Survey, Vol. VI. (Cretaceous Flora), by Leo Lesquereux.

SPECIMENS SHOWN.

White and colored clays, pyrite nodules and lignite. Glen Cove, L. I.
Plant remains in clay. Northport, L. I.
Plant remains in sandstone, from the drift at Brooklyn, L. I.
Plant remains in concretions, from the drift near Glen Cove, L. I.
Plant remains in red shale, from clay outcrop on the shore near Glen Cove, I.

ON ANTENNÆ AND OTHER APPENDAGES OF TRIARTHRUS BECKII.

BY W. D. MATTHEW.

(Plate VIII.)

Among the problems which palæontologists have in vain tried to solve was, till a few years ago, that of the structure and affinities of the trilobite. In all the vast numbers of these animals which have been found and studied, scarcely any parts have been preserved, other than the dorsal shield and hypostome. The legs, gills, etc., have practically never been shown on any specimen. This is chiefly because of the easy break afforded by the hard, smooth carapace, but, partly also, because of the character of these organs, which seem to have been soft, easily disjointed, and prone to maceration and decay. The only cases, as far as I know, in which the organs of the under side have been definitely seen and described, are three specimens of *Asaphus platycephalus* in which a number of legs are preserved in a fragmentary way ; another of the same genus, showing a palpus attached to the hypostome, and a few cases where a detached leg or antenna was found in company with species of trilobites, and referred to one of them. Other discoveries have been reported at various times, but not conclusively verified.

It has, however, been found possible by cutting thin sections of trilobites especially well preserved in limestone, to determine the nature and position of the organs of the under side. Mr. C. D. Walcott in 1881, published the results of a very successful investigation of this kind, extending over several years, and based on the study of over 2,000 thin sections. His article has given us a very complete knowledge of the organization, at least of the two genera, *Ceraurus* and *Calymene*, which were the subjects of his study.

The structure as thus determined was :

1. A *ventral membrane* over the under side of the body, with hardened arches across each segment bearing the appendages.

2. *Cephalic limbs.* There are four pairs of these, the last of which is larger and expanded at the terminal joint into a swimming organ. The bases of these limbs were manducatory in their action.

3. *Thoracic abdominal appendages.* One pair of legs was found to be attached to each segment of the thorax and pygidium. On the basal joint of each was a small epipodite, and two branchiæ which were in the form of narrow spiral ribbons. The legs, like those of the head, were generally composed of six joints, which were more or less conical, the basal end smallest. Other forms of gills were also found, a straight uncoiled ribbon in immature specimens, and a radiating leafy form confined to the anterior part of the thorax. There is no mention of cephalic gills.

4. No trace of an *antennal system* was found.

Mr. Walcott concludes that the trilobites were more nearly allied to the Limulids than to any other living form, and should be classed with them and the Eurypterids, but as a separate subclass. As to their habits, he concludes that they probably were free swimming only when young, and crawled around on the bottom when mature.

Mr. W. S. Valiant has found a very considerable number of specimens of Triarthrus Beckii, in which the organs of the under side are attached to the body and fairly well preserved. They occur in the Hudson River shales* near Rome, N. Y. A number of the best specimens are now in the museum of

* Though referred to the Hudson River by Mr. Valiant, Prof. Whitfield is disposed, on palæontological grounds, to consider them as Utica shales.

Columbia College, and Prof. Kemp very kindly has given me the privilege of describing them.

The trilobites are found in a soft, fine, black shale, and are very perfectly preserved. The most noticeable character about them is the presence of long, many-jointed, rod-like attachments to the front of the head, which resemble exactly the antennæ of other crustaceans. These come out close together from just under the centre of the anterior border of the head-shield, and diverge generally at an angle of 30° or 40°. In one specimen (Fig. 1), a length considerably exceeding that of the glabella is shown* ; in the rest, they are more broken, but a considerable length is preserved in three or four, and the stumps are distinctly seen in upwards of twenty others. They curve slightly outward and taper gradually down towards the end ; the tip itself is not preserved. These antennæ are composed of a great number of joints, each of which is conical, about half as long as wide, and smallest at the base of the joint. (See Fig. 1[a].) As preserved, they are calcareous, but apparently of a structure less firm and thick than the substance of the carapace. Their point of origin appears to be under the front of the glabella, as they can be traced a little way under the head-shield, where they almost coalesce, then diverge and disappear ; no joints are distinguishable in this part. (See Fig. 2.) Just over where they come out, the anterior rim is arched slightly upward, seemingly to give room for their play to and fro.

These organs must certainly belong to the trilobite ; when attached, they are in all cases in exactly the same position, and are but rarely to be seen separate ; moreover, in a number of specimens in which they were not shown, they were developed by cutting away the matrix in the proper place. Their character seems also tolerably certain, as both in position and structure they are like the antennæ of modern crustaceans. The appearance of the right hand antenna in Fig. 3, may indicate that these organs could be bent back under the sides of the shield—but this point needs more evidence.

Besides these, there are shown in several of the specimens, other appendages, some of which may be branchial in their character, and others, walking or swimming legs. In Fig. 1, the side of the head shield has been broken away, exposing the appendages, apparently of three cephalic segments. These are of two kinds, one of which seems to be a narrow, jointed,

* Mr. Valiant has since shown me a specimen which has antennæ one and a half times as long as the glabella. He informs me that there are now about sixty specimens showing antennæ.—June, 1893.

cylindrical leg, and the other is thin, broad and leafy, with what seems to be a comb-like structure similar to the gills of many crustacea. These branchiæ, if so they be, depend from a narrow, thickened anterior edge or limb; they seem to correspond with two of the three cephalic (?) legs shown in the specimen, and to overlie them. By analogy with Mr. Walcott's determinations, they are probably attached to the basal joints of the leg.

In Figs. 2, 3 and 6 are shown the ends of appendages, which projected from under the carapace, and seem to belong to the thoracic region. These are likewise of two kinds, one of which shows an oblique comb-structure or system of parallel lines (see Figs. 2, 2^a, 3 and 4); and the other is a strong tapering leg, with three cylindrical or slightly flaring joints visible (see Figs. 2, 2^a, 3, 5 and 6). The first may be a branchial appendage; it is flat and appears to broaden into a small paddle at the tip, though this appearance may be deceptive; it has a sharp ridge and narrow furrow along the anterior edge, and behind that, the series of lines or comb-like structure, which may be due to the remains of hairs or gill-structure on the limb.

Figure 4 shows a series of appendages of both kinds, but very poorly preserved. In Fig. 7, the projecting appendages of the tail-piece are shown, and it may be seen that apparently several, and perhaps all of the pygidial limbs are anchylosed, so as to make a rounded flap, which in shape, though not in structure, reminds one of the telson of a crayfish, and perhaps served the same purpose—to propel the animal backwards through the water.

The conclusions as to the nature of these appendages are only provisional, and may be much changed by further discoveries. They are not nearly as well preserved as the antennæ, nor in so considerable a number of specimens; as besides those figured, there are only two or three others which show them at all, and those, only traces. The shape and structure of the supposed branchiæ, in particular, are very hard to distinguish; the figures given, however, represent, as far as I can see, the actual outline preserved.

It will be seen that the structure of *Triarthrus* must have differed not a little from that described by Mr. Walcott in *Calymene* and *Ceraurus*. The presence of antennæ, the broad, leafy gills, and the anchylosed flap under the pygidium (providing that the two latter are correct interpretations of the structure) are all important points of difference, and indicate that the Trilobites were quite varied in structure, and probably included a number of widely differing forms. If the classification founded on the characters of the shield is not deceptive, we may, perhaps, consider that the structure of *Triarthrus* was that of all the *Olenidæ*, the family to which it belongs; while many of the later trilobites would come nearer to *Calymene* and *Ceraurus* in their structure.

As regards the probable affinities of the trilobite as modified by Mr. Valiant's discovery, the writer can scarcely venture any remarks, except tentatively. The homology with *Limulus* seems not to be as close in *Triarthrus* as in the forms studied by Mr. Walcott; but the characters seem to be of a more comprehensive type, approaching the general structure of the other crustacea rather than that of any special form. The presence of antennæ need not, one would think, separate them from the rest of the Pœcilopoda, for a small pair occurs in *Eurypterus*, and the anterior pair of appendages in *Limulus* are also thought to be modified antennæ. The cephalic organs are peculiar, if proved to be gills, and though in the solitary specimen showing them they seem to belong to the head, yet further proof would be desirable, that they are not displaced, thoracic limbs. The fused pygidial flap would be a less important character, as it might easily be induced by change of conditions of life.

As regards the habits of Triarthrus, we may conjecture that it usually scuttled through the soft mud which composed the shale in which it is found, on the little pointed walking legs; but that it had considerable swimming powers, more, perhaps, than the later types of trilobites.

It is hardly to be expected that these antennæ, still less the other organs, will be found in specimens of trilobites unless they be exceptionally well preserved; but one character, the arching of the anterior rim at the centre of the head—if not a mere accident of preservation in these specimens—may be found to exist in less perfect fossils, and would be a fair indication of the former existence of the antennæ which passed under it.

In conclusion, I wish to acknowledge the kindness of Prof. Kemp in allowing me the honor of describing these specimens. I have also to thank Prof. Whitfield for advice and assistance in the subject, which has been very useful to me.

[NOTE.—As regards the supposed gills under the head, it would seem more probable that they were long, thickly set hairs or fimbriæ on a narrow limb, and served as mouth organs rather than gills, though, perhaps, also assisting in the respiration.—June, 1893.

May 29, 1892.

Stated Meeting.

President Bolton in the chair, and fifteen persons present.

Dr. Marcus Benjamin read a paper entitled: "The Development of Science in New York City."

June 5, 1893.

Regular Business Meeting.

President Bolton in the chair, and five persons present.

The following papers were read by title: "The Chordeumidæ of North America," by O. F. Cook and F. P. Collins.

NOTE ON THE POSITION OF THE CLOACAL APERTURE IN CERTAIN BATRACHIAN TADPOLES.

BY ARTHUR WILLEY.

An interesting feature in connection with the study of Teratology is concerned with disturbances in the topographical relations of parts produced by mechanical means or, in other words, by the differential growth of neighboring structures.

One of the effects of such disturbances introduced secondarily into the life-history of an organism, is to give rise to a condition of asymmetry in the relations of this or that organ. At its first appearance, in whatever form, an asymmetrical condition must be regarded as anomalous, and we thus arrive at the paradoxical conclusion that an anomaly may, on being fixed and rendered constant by inheritance from generation to generation, become the normal state of things. This is only another way of saying that, "La tératogénie est capable de produire des espèces nouvelles." (See Paul Hallez, "Morphogénie générale et affinités des Turbellariés." Lille 1892.)

While examining recently a number of tadpoles, which were identified with the assistance of Mary H. Hinckley's paper "On Some Differences in the Mouth Structure of Tadpoles of the Anourous Batrachians found in Milton, Mass.," (Proc. Bost. Soc. Nat. Hist. XXI., 1881, pp. 307-314, Pl. V.), as the probable larvæ of *Rana clamata* (= *R. fontinalis*), I observed that the cloacal aperture was usually placed distinctly to the right of the middle line.

Ventrally, at the point where the tail joins on to the body,

Fig. 1.

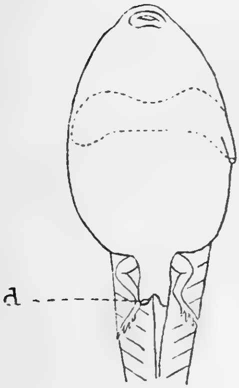


Fig. 2.

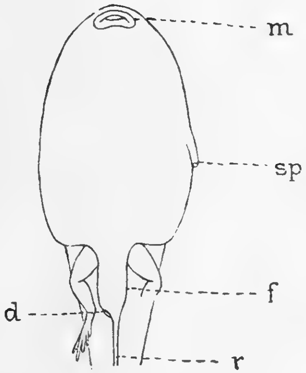
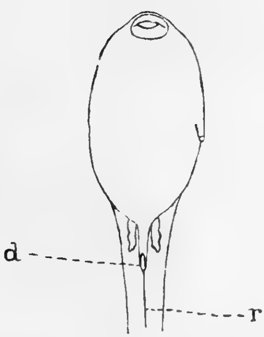


Fig. 3.



Explanation of Figs. 1-3: Three tadpoles of *Rana clamata* from ventral aspect. Slightly enlarged; *m*, mouth; *sp*, spiraculum; *f*, loose fold of integument; *r*, raphe of tail; *d*, cloacal aperture. The dotted line in Fig. 1 indicates the limits of the peri-branchial chamber.

there is a loose fold of the integument continuous behind with the median raphe or keel of the tail. The cloacal aperture occurs at the end of a small papilla, which is often completely hidden beneath this loose fold on the right side of it. The cloacal papilla, however, undergoes varying degrees of concrescence with the fold and, accordingly, sometimes the aperture lies quite near the extremity of the latter, but still somewhat to the right of the middle line, as in Fig. 2.

In one case only, out of the many that I examined, was the cloacal aperture placed on the mid-ventral line, as in Fig. 3.

In another isolated instance, a very striking condition was observed (see Fig. 1). The hinder end of the above-mentioned loose integumentary fold was bifid, and presented at first sight, a perfectly symmetrical appearance. On close inspection, however, it became evident that the left half of the fold was continuous with what has been referred to above as the raphe or keel of the tail, while the right half hung freely and bore the cloacal aperture at its tip.

I am not aware that attention has ever been drawn to this asymmetrical position of the cloacal aperture in the Batrachian tadpole, nor to what extent it occurs in other species. It is certainly not universal. In the tadpoles of *Bufo lentiginosus* for instance, the external opening of the cloaca lies normally in the mid-ventral line, whereas, we have seen that in those of *R. clamata* the asymmetrical position is the usual one, and the median position is the exception.

Héron-Royer and Ch. van Bambeke, in their researches on "Le vestibule de la bouche chez les têtards des batraciens anoures d'Europe," (Archives de Biologie IX., 1889, pp. 185-309, Pl. XII.-XXIV.), give diagnoses of the different tadpoles examined by them, but make no mention of any peculiarity in the position of the cloacal orifice.

It is interesting to call to mind the well-known fact, that in the lung-breathing fish, *Protopterus*, there is an analogous asymmetry in the position of the cloacal aperture, lying as it does, now to the right and now to the left of the median line, (cf. Wiedersheim, Lehrbuch d. vergl. Anat. der Wirbelthiere, 2 Auflage, 1886, p. 563). In the specimen of *Protopterus annectens* in the adjoining Geological Museum, it lies to the *left* of the middle line, being placed at the side of a mesial fold of the skin, which is of precisely the same nature as that described above for the tadpole of *R. clamata*.

It also recalls the condition of things in *Amphioxus*, where the anus lies constantly on the left side of the body, above the caudal fin.

In connection with the above-described variability in the position of the cloacal aperture it may be well to refer to the observation of Mary H. Hinckley ("Note on the development of *Rana sylvatica*, Leconte," Proc. Boston Soc. Nat. Hist. XXII., 1882, pp. 85-95), that among tadpoles of *R. sylvatica* and *R. halecina* (= *R. virescens*) individuals are occasionally met with having two branchial pores or spiracula situated on the right and left sides of the body respectively*, the usual condition of course being, to have only the left spiraculum persisting. As is well-known, in the tadpoles of *Alytes*, *Bombinator* and *Discoglossus*, the single spiraculum is placed in the mid-ventral line.

The fact of the asymmetrical position of such apertures as those spoken of above, to which may be added the olfactory pit of Amphioxus which lies on the left side of the body, together with the fact that as a rule their position on this or that side of the body is remarkably constant, looks very much like an acquired character which has been fixed by inheritance. It can be no conceivable advantage to an animal to have, as in *Amphioxus*, for instance, the anus to the left rather than to the right of the integumentary expansion which forms the caudal fin, but its constant position on the left side becomes intelligible, if it is regarded as an acquired characteristic which has become inherited. The same argument applies to the (somewhat less) constant position, to the right of the middle line, of the cloacal aperture in the tadpoles of *R. clamata*.

Columbia College, May 26, 1893.

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* This is the normal condition in *Dactylethra*

INDEX.

PLATE I.

FIG. 1. *Juniperus hypnoides*, Heer. Kreischerville.

FIGS. 2 and 3. *Williamsonia* (?) *Riesii*, n. sp. Kreischerville.

FIGS. 4, 6, 8, 11, 12, 14, 15, 16 and 16*a*. Fruits and seeds. Kreischerville, Tottenville, and Green Ridge.

FIG. 5. *Sequoia Couttsiæ*, Heer. Kreischerville.

FIG. 7. *Majanthemophyllum pusillum*, Heer. Kreischerville.

FIG. 9. *Dewalquea insignis*, Hos. Kreischerville.

FIG. 10. *Phyllites Poinsettioides*, n. sp. Kreischerville.

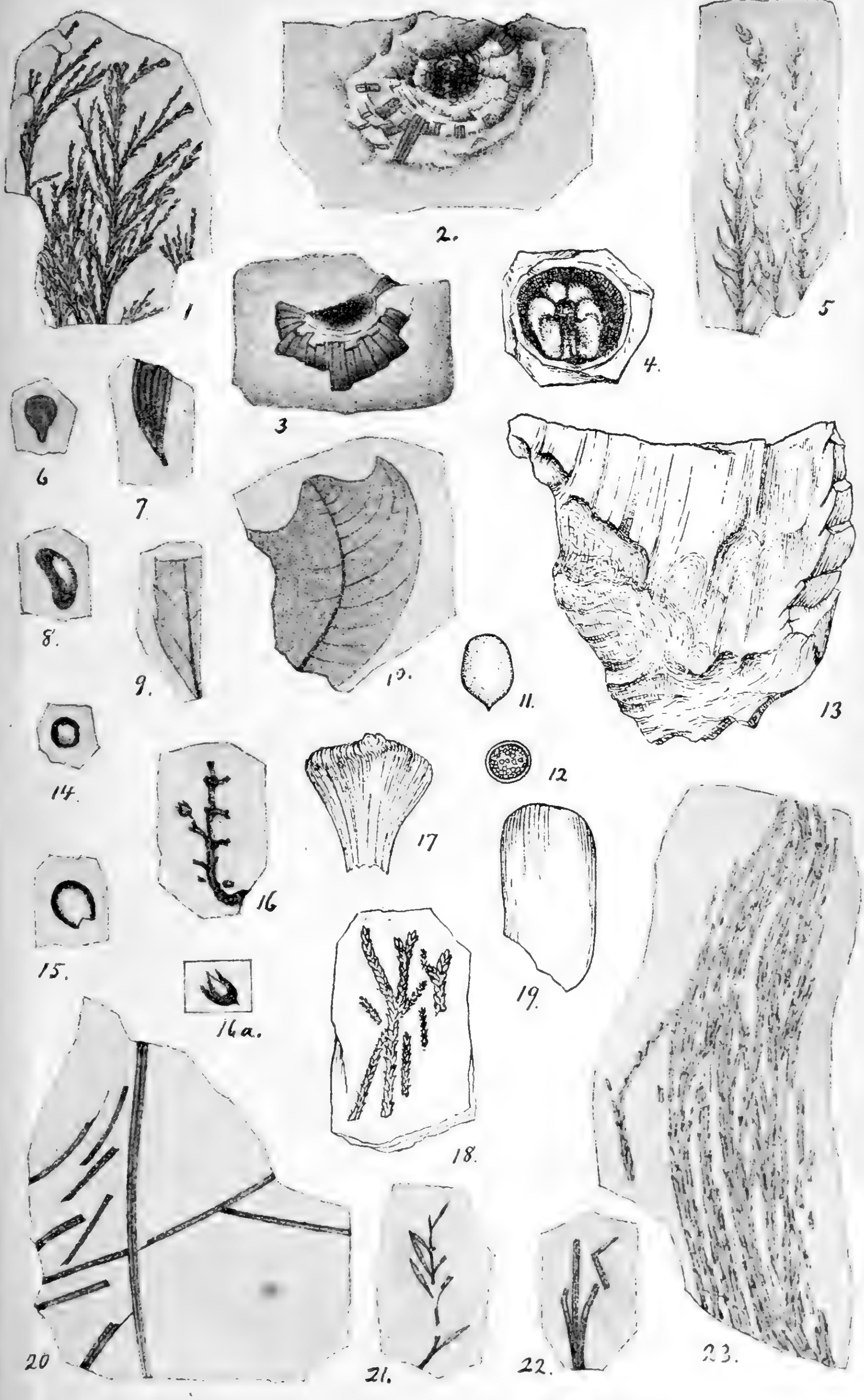
FIGS. 13, 19, 20, 22. *Pinus* sp.? Kreischerville, Tottenville, and Arrochar.

FIG. 17. *Dammara borealis*, Heer? Tottenville.

FIG. 18. *Sequoia Reichenbachi*, Gein? Tottenville.

FIG. 21. *Sequoia heterophylla*, Vel. Kreischerville.

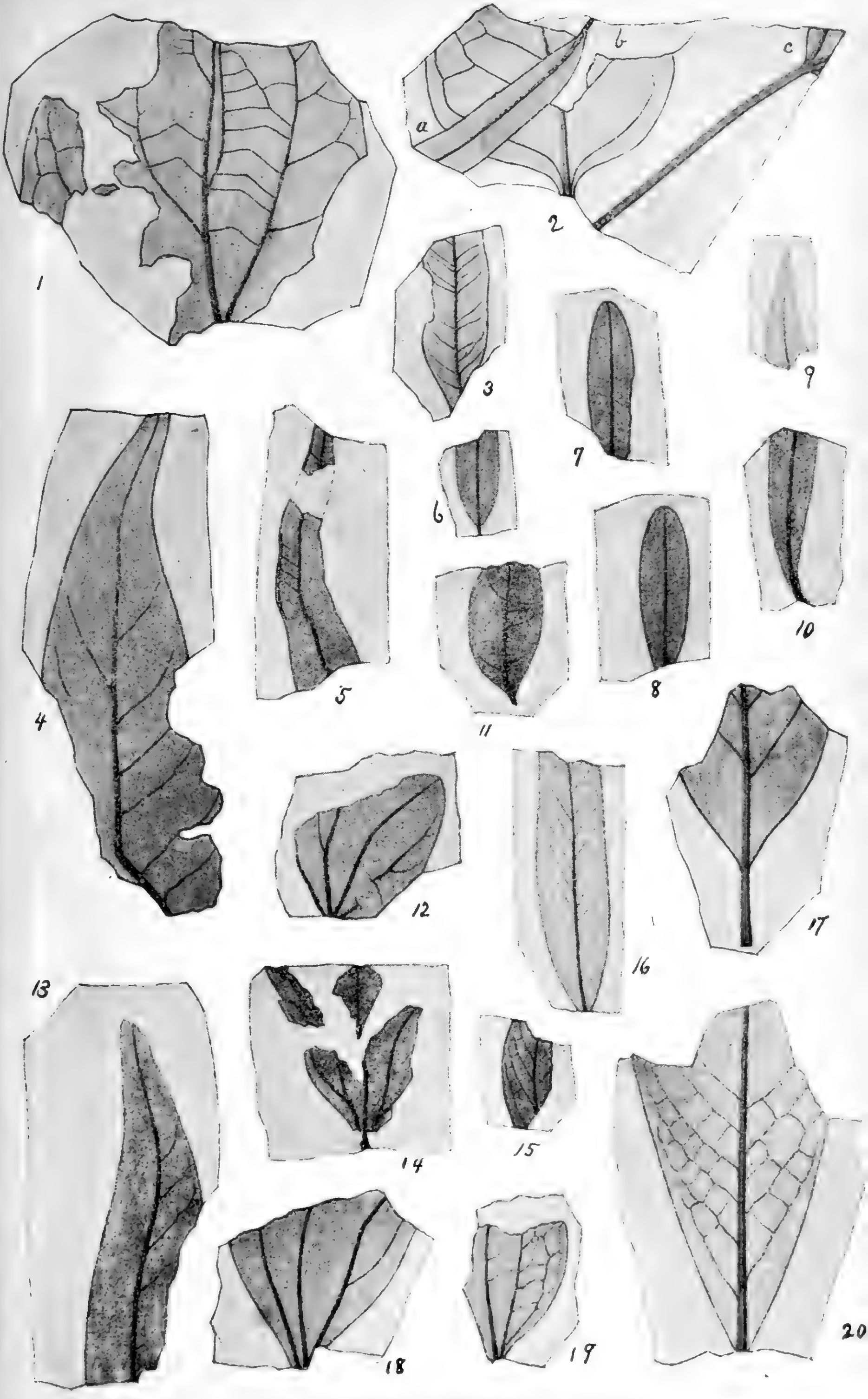
FIG. 23. *Frenelites Reichii*, Ett. Kreischerville.



STATEN ISLAND CRETACEOUS FLORA.

PLATE II.

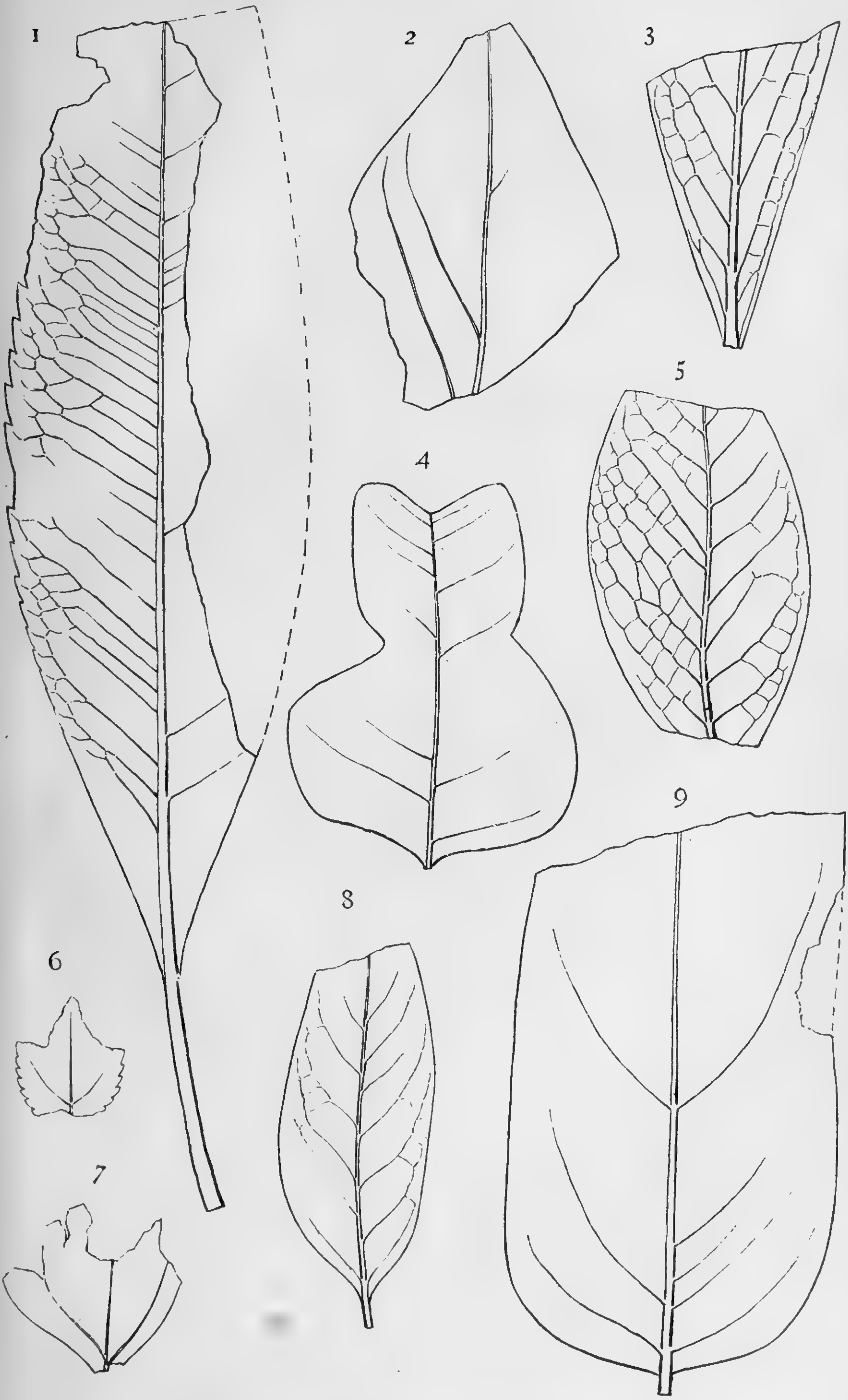
FIGS. 1 and 2*c*. *Ficus Woolsoni*, Newb. in mss.? Kreischerville.
FIG. 2*b*. *Chondrophyllum orbiculatum*, Heer: Kreischerville.
FIG. 3. *Myrica Davisii*, n. sp. Kreischerville.
FIGS. 4, 9 and 13. *Protœoides Daphnogenoides*, Heer. Kreischerville.
FIG. 5. *Eucalyptus Geinitzi*, Heer. Kreischerville.
FIGS. 6, 7 and 8. *Kalmia Brittoniana*, n. sp. Kreischerville.
FIGS. 10 and 2*a*. *Dewalquea Haldemiana*, Sap.? Kreischerville.
FIG. 11. *Leguminosites frigidus*, Heer. Kreischerville.
FIGS. 12, 14, 18 and 19. *Paliurus affinis*, Heer.? Kreischerville.
FIGS. 15 and 16. *Salix*, sp.? Kreischerville.
FIG. 17. *Laurus Hollæ*, Heer.? Kreischerville.
FIG. 20. *Laurus primigenia*, Ung.? Kreischerville.



STATEN ISLAND CRETACEOUS FLORA.

PLATE III.

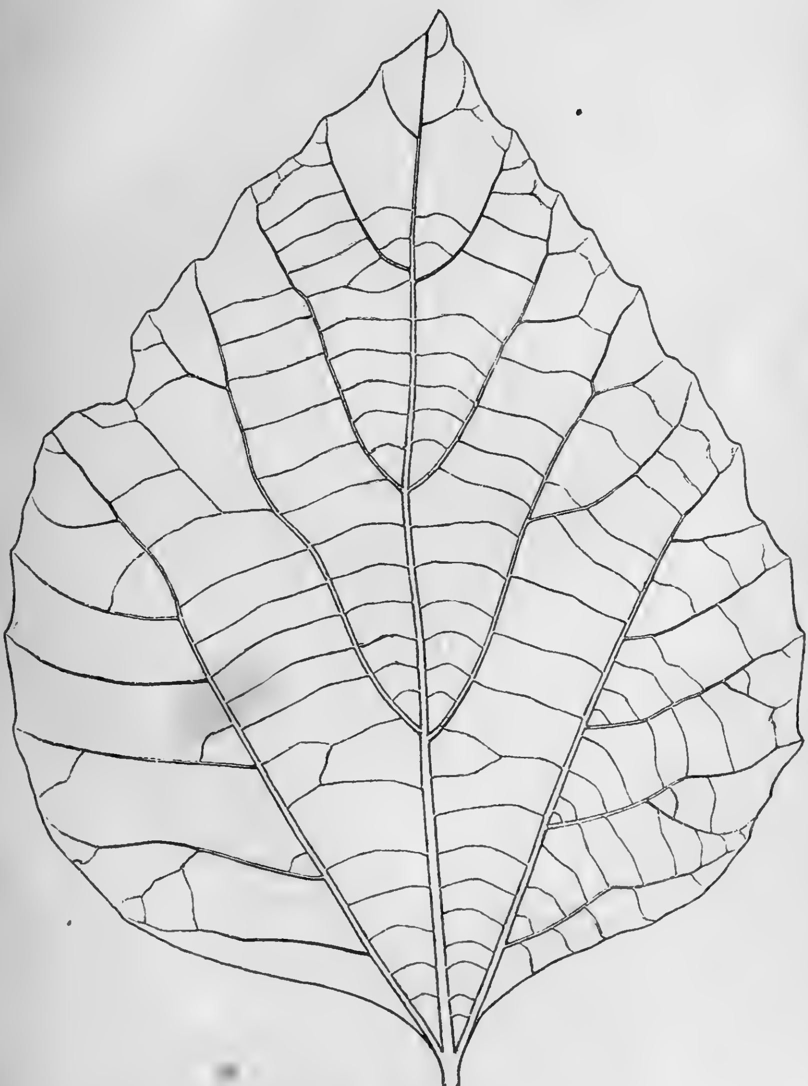
FIG. 1. *Myrica grandifolia*, n. sp. Tottenville.
FIG. 2. *Populus* (?) *apiculata*, Newb. in mss.? Arrochar.
FIG. 3. *Laurus primigenia*, Ung.? Tottenville.
FIG. 4. *Liriodendron primævum*, Newb. Tottenville.
FIG. 5. *Rhamnus Rossmassleri*, Ung. Tottenville.
FIG. 6. *Acer minutus*, n. sp. Tottenville.
FIG. 7. *Paliurus affinis*, Heer.? Tottenville.
FIG. 7. *Diospyros Steenstrupi*, Heer. Tottenville.
FIG. 9. *Magnolia longifolia*, Newb. in mss. Tottenville.



STATEN ISLAND CRETACEOUS FLORA.

PLATE IV.

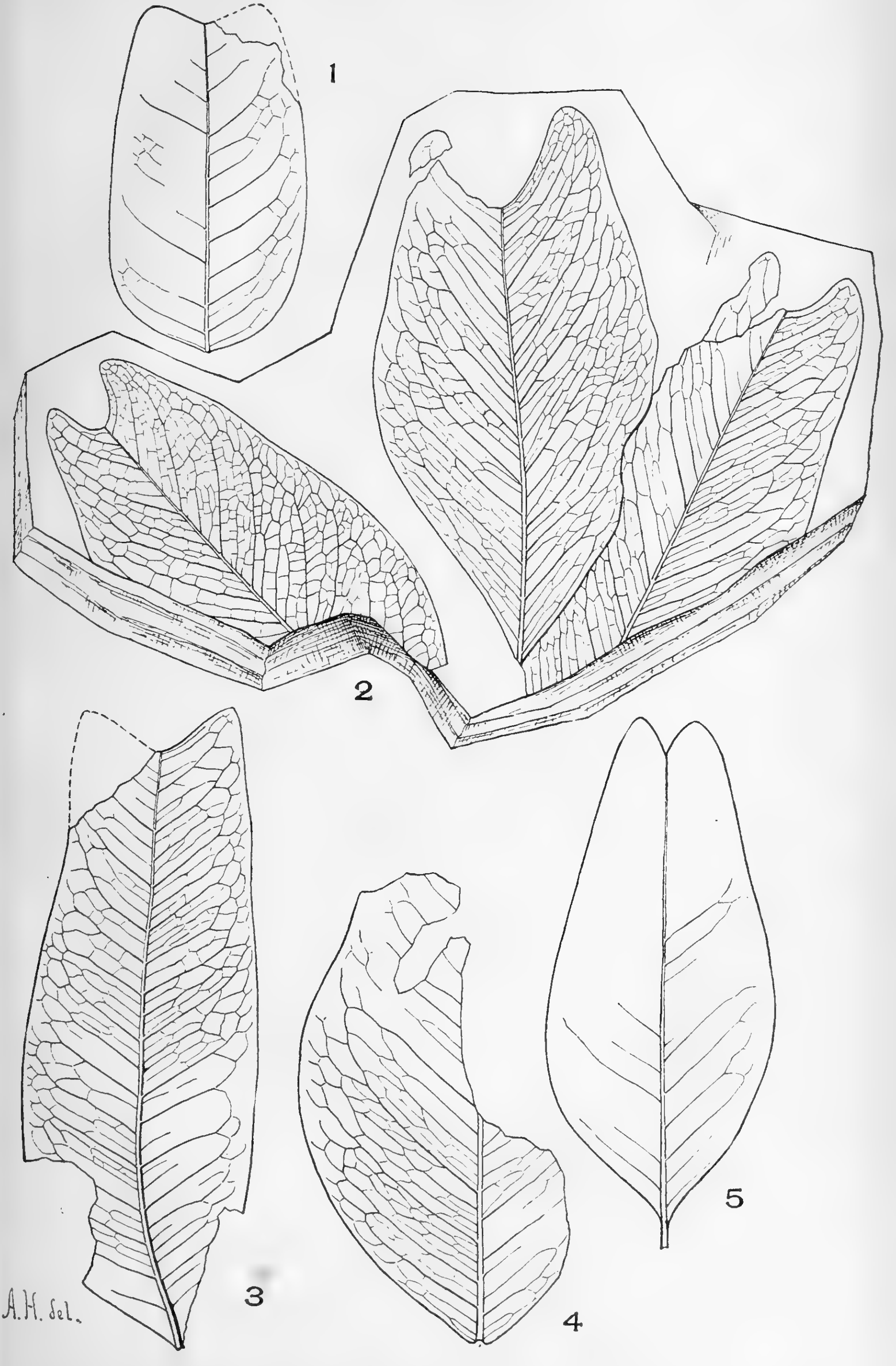
Platanus Aquehongensis, n. sp. Richmond Valley.



STATEN ISLAND CRETACEOUS FLORA.

PLATE V.

Figs. 1—5. *Liriodendron simplex*, Newb. Glen Cove, Long Island, N. Y.



LONG ISLAND CRETACEOUS FLORA.

PLATE VI.

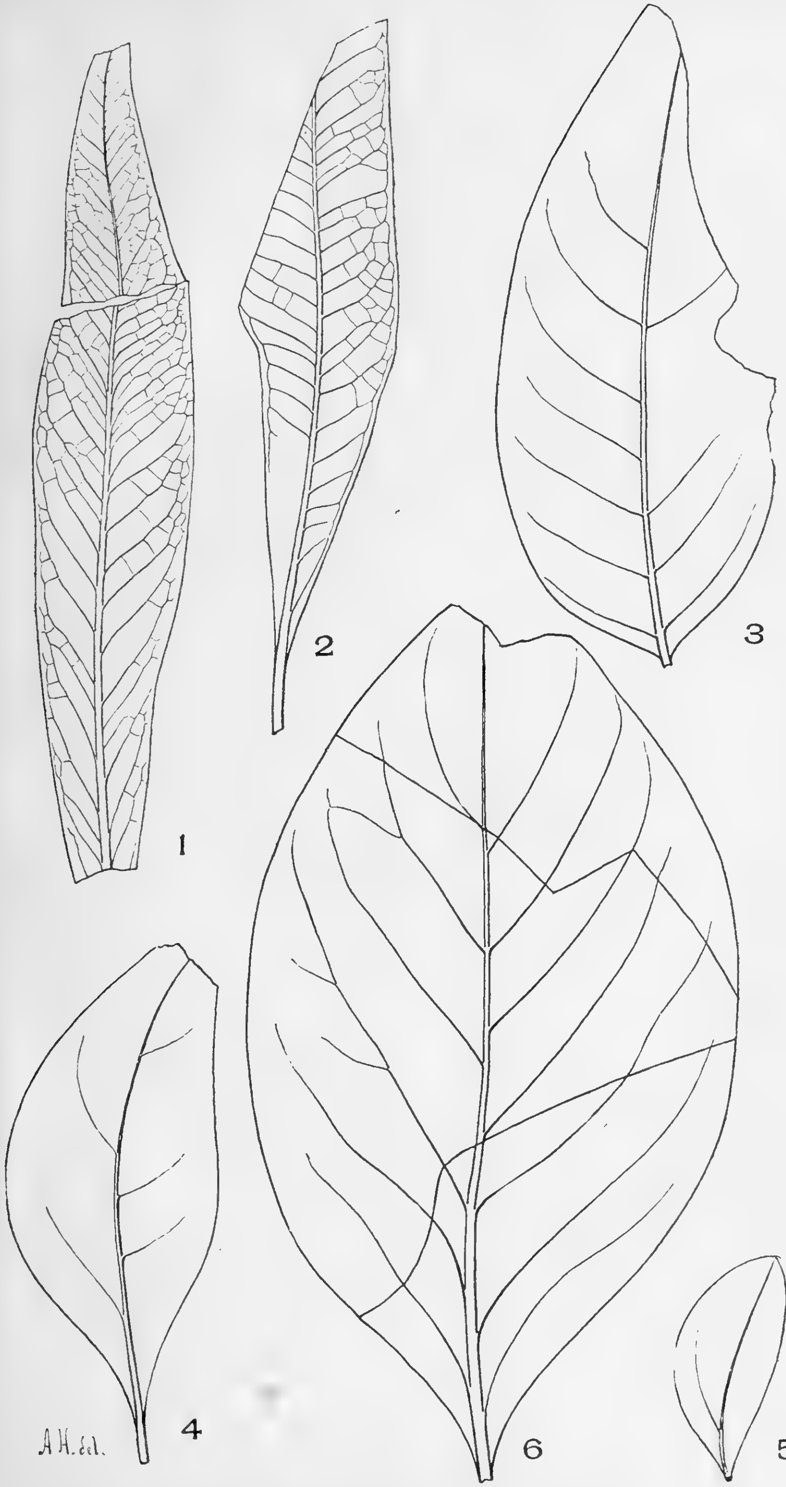
Fig. 1. *Laurus Plutonia,* Heer. Glen Cove, Long Island, New York.

Fig. 2. *Myrtophyllum* (*Eucalyptus?*) *Geinitzi,* Heer. Glen Cove, Long Island, N. Y.

Fig. 3. *Sapindus Morrisoni,* Lesq. Glen Cove, Long Island, N. Y.

Figs. 4—5. *Dalbergia Rinkiana,* Heer. No. 4 from Williamsburg (Brooklyn) Long Island, N. Y. No. 5 from Lloyd's Neck, Long Island, N. Y.

Fig. 6. *Magnolia Capellini,* Heer. Glen Cove, Long Island, N. Y.



LONG ISLAND CRETACEOUS FLORA

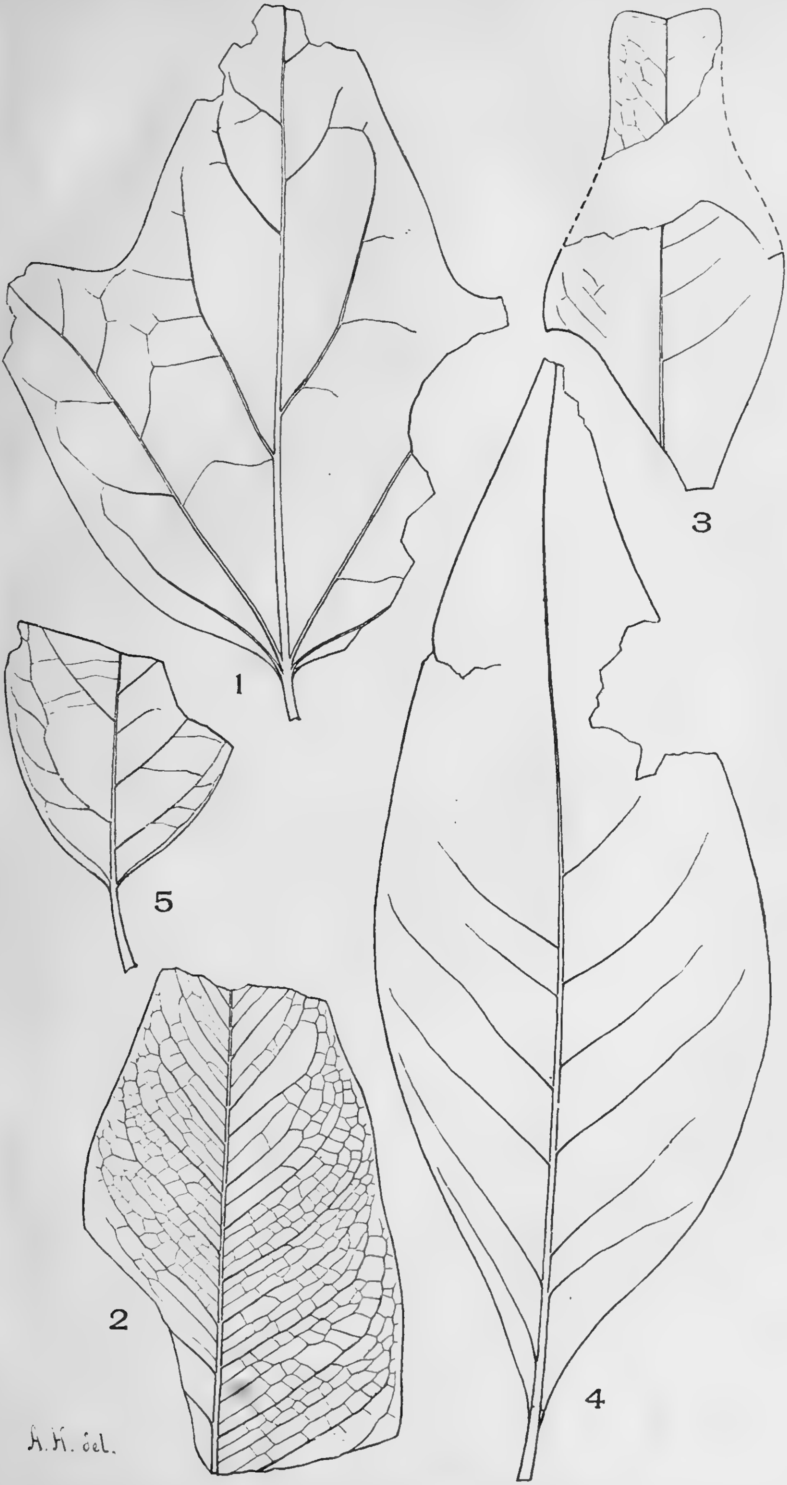
PLATE VII.

Fig. 1. *Sassafras* (*Araliopsis*) *acutilobum*, Lesq. Glen Cove, Long Island, N. Y.

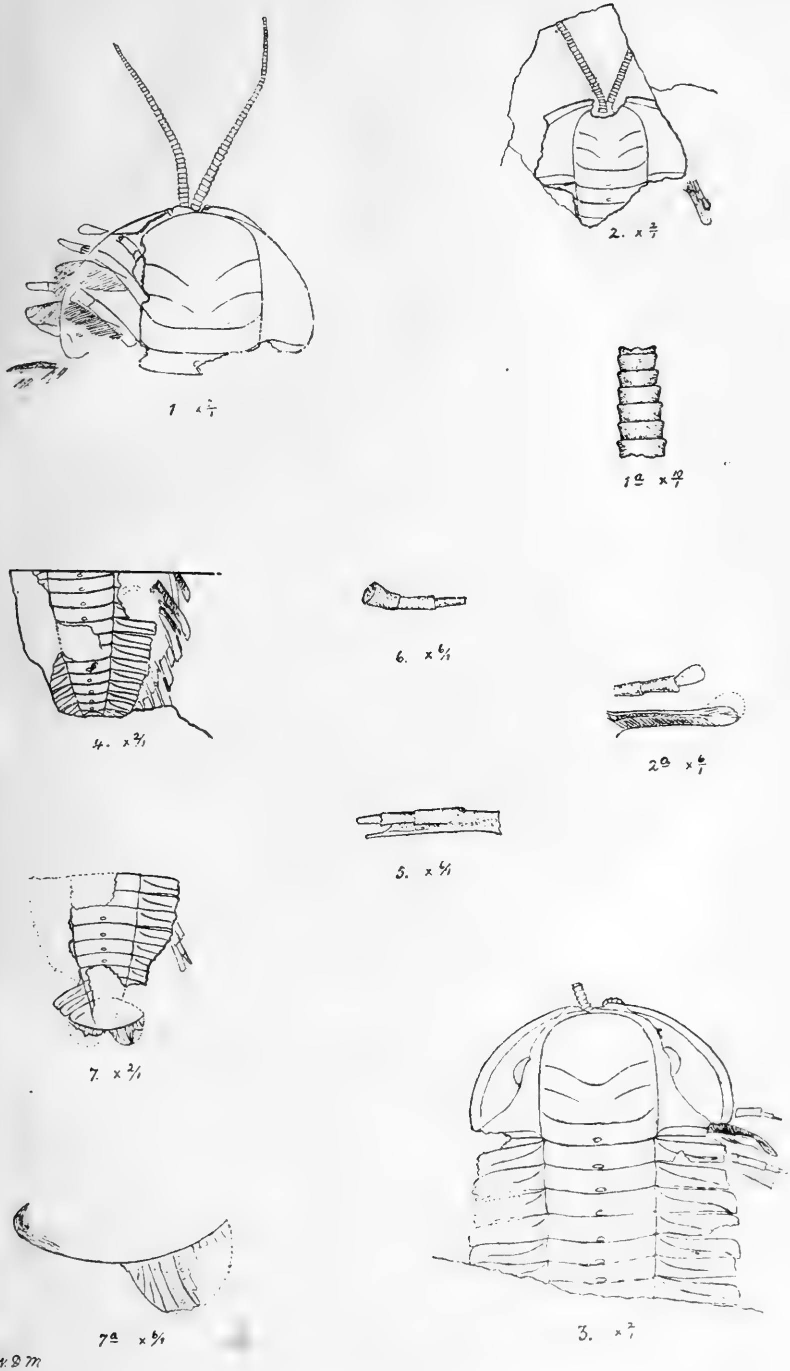
Figs. 2—3. *Liriodendron simplex*, Newb. Glen Cove. Long Island, N. Y.

Fig. 4. *Magnolia speciosa*, Heer. Glen Cove, Long Island, N. Y.

Fig. 5. *Diospyros primæva*, Heer. Glen Cove, Long Island, N. Y.



LONG ISLAND CRETACEOUS FLORA.



APPENDAGES OF TRIARTHRUS BECKII.

LIST OF EXCHANGES.

The following Societies and Institutions exchange publications with the Academy.

(The number following each title indicates the position of the publication on the shelves of the library. Members of the Academy desiring to consult any of these works are requested to cite the title *and number*, as this will save loss of time in searching or consulting catalogues.)

J. F. Kemp,
Librarian.

North America.

United States.

The New York State Library, Albany, N. Y. 027.
The New York State Museum of Natural History, Albany, N. Y. 507.
The New York State Dairy Commission, Albany, N. Y. 637.
Amherst College, Amherst, Mass. 378.
The University of Michigan, Ann Arbor, Mich. 378.
U. S. Naval Academy Library, Annapolis, Md. 027.
The Texas Academy of Sciences, Austin, Texas. 506.1.
The Biological Laboratory, Johns Hopkins University, Baltimore, Md. 507.
The Maryland Academy of Sciences, Baltimore, Md. 506.1.
The University of California, Berkeley, Cal. 378.
Blue Hill Meteorological Observatory, Blue Hill, Mass. 551.5.
The Boston Society of Natural History, Boston, Mass. 506.1.
The Ornithologist and Oölogist, Boston, Mass. 598.2.
The Boston Public Library, Boston, Mass. 027.
The Brooklyn Library, Brooklyn, N. Y. 027.
The Long Island Historical Society, Brooklyn, N. Y. 906.

The Brookville Society of Natural History, Brookville, Ind. 506.1.

Bowdoin College, Brunswick, Me. 378.

The Buffalo Historical Society, Buffalo, N. Y. 906.

The Buffalo Society of Natural Sciences, Buffalo, N. Y. 506.1.

The American Academy of Arts and Sciences, Boston, Mass. 506.1.

The Astronomical Observatory at Harvard College, Cambridge, Mass. 522.1.

Harvard University, Cambridge, Mass. 378.

The Museum of Comparative Zoology at Harvard College, Cambridge, Mass. 507.

The Peabody Museum of American Archæology and Ethnology, Cambridge, Mass. 571.

The Illinois State Laboratory of Natural History, Champaign, Ill. 507.

The Elisha Mitchell Scientific Society, Chapel Hill, N. C. 506.1.

Elliott Society of Science and Art, Charleston, S. C. 506.1.

The University of Chicago, Chicago, Ill. 378.

The American Chemical Review, 242 Burling street, Chicago, Ill. 540.5.

The Cincinnati Society of Natural History, 108 Broadway, Cincinnati, Ohio. 506.1.

Cincinnati Observatory, Cincinnati, Ohio. 522.1

The Ohio Mechanics' Institute, Cincinnati, Ohio. 506.1.

Hamilton College, Clinton, N. Y. 378.

Ohio State University, Columbus, Ohio. 378.

The Academy of Natural Sciences, Davenport, Iowa. 506.1.

The Colorado Scientific Society, Denver, Col. 506.1.

The Iowa Academy of Sciences, Des Moines, Iowa. 506.1.

The New York Microscopical Society, care of Rev. J. L. Zabriskie, Waverly ave., Flatbush, N. Y. 578.

Denison University, Granville, Ohio. 507.

The American Antiquarian and Oriental Journal, Good Hope, Ill. 571.

Dartmouth College, Hanover, N. H. 378.

Trinity College, Hartford, Conn. 378.
The Department of Geology and Natural History, Indianapolis, Ind. 557.72.
Cornell University, Ithaca, N. Y. 378.
The Kansas University Quarterly, Lawrence, Kan. 378.
The Geological Survey of Arkansas, Little Rock, Ark. 557.67.
The Wisconsin Academy of Sciences, Madison, Wis. 506.1.
The University of Wisconsin, Madison, Wis. 378.
Meriden Scientific Association, Meriden, Conn. 506.1.
Wesleyan University, Middletown, Conn. 507.
The Natural History Society of Wisconsin, Milwaukee, Wis. 506.1.
The Public Museum, Milwaukee, Wis. 507.
The Minnesota Academy of Natural Sciences, Minneapolis, Minn. 506.1.
The Geological and Natural History Survey of Minnesota, Minneapolis, Minn. 557.76.
Geological Survey of New Jersey, New Brunswick, N. J. 557.49.
Rutgers College, New Brunswick, N. J. 378.
The Connecticut Academy of Arts and Sciences, New Haven, Conn. 506.1.
Yale University, New Haven, Conn. 378.
The Newport Scientific Society, Newport, R. I. 506.1.
The New Orleans Academy of Sciences, New Orleans, La. 506.1.
Columbia College, New York. 378.
The American Chemical Society, N. Y. University, New York. 540.6.
The American Institute of Mining Engineers, 13 Burling slip, New York. 622.6.
The American Geographical Society, 11 W. 29th street, New York. 910.6.
The American Museum of Natural History, New York. 507.
The Astor Library, New York. 027.
The Torrey Botanical Club, New York. 580.6.

The College of the City of New York, New York. 378.
The Mercantile Library Association, New York. 027.
The New York Historical Society, 70 Second ave., New York. 906.
The University of the City of New York, New York. 378.
The Scientific Association, Peoria, Ill. 506.1.
The Portland Natural History Society, Portland, Maine. 506.1.
The Academy of Natural Sciences of Philadelphia, Philadelphia, Pa. 506.1.
The American Philosophical Society, Philadelphia, Pa. 506.1.
The Engineers' Club of Philadelphia, Philadelphia, Pa. 620.6.
The Polyclinic, Philadelphia, Pa. 910.
The Zoological Society of Philadelphia, Philadelphia, Pa. 590.6.
The Franklin Institute, Philadelphia, Pa. 506.1.
The Wagner Free Institute of Science, Philadelphia, Pa. 506.1.
The Vassar Brothers' Institute, Poughkeepsie, N. Y. 506.1.
The E. M. Museum of Geology and Archæology, Princeton, N. J. 507.
The University of Rochester, Rochester, N. Y. 378.
Geological Society of America, care of Prof. H. L. Fairchild, Rochester University, Rochester, N. Y. 550.6.
The Warner Observatory, Rochester, N. Y. 522.1.
The California State Mining Bureau, San Francisco, Cal. 622.
The American Association for the Advancement of Science, Salem, Mass. 506.1.
The Essex Institute, Salem, Mass. 506.1.
The Peabody Academy of Science, Salem, Mass. 506.1.
The San Francisco Microscopical Society, San Francisco, Cal. 578.
The California Academy of Sciences, San Francisco, Cal. 506.1.
Union College, Schenectady, N. Y. 378.
The Academy of Sciences, St. Louis, Mo. 506.1.
The Missouri Botanic Garden, St. Louis, Mo. 580.7.
The Library of Syracuse, Syracuse, N. Y. 027.
The University of Syracuse, Syracuse, N. Y. 378.
The Natural Science Association of Staten Island, care of Jos. C. Thompson, Rosebank, N. Y. 506.1.

The Kansas Academy of Sciences, Topeka, Kan. 506.1.
The Washburn College Laboratory of Natural History, Topeka, Kan. 507.
The Trenton Natural History Society, Trenton, N. J. 506.1.
The Geological Survey of Alabama, University, Ala. 557.61.
The American Antiquarian Society, Worcester, Mass. 571.
The Bureau of Ethnology, Washington, D. C. 572.
The Philosophical Society, Washington, D. C. 506.1.
The Congressional Library, Washington, D. C. 027.
The Chief of Engineers, U. S. A., Washington, D. C. 620.
The Smithsonian Institution, Washington, D. C. 506.1.
The Sedalia Natural History Society, Sedalia, Mo. 506.1.
United States Bureau of Education, Department of the Interior, Washington, D. C. 370.7.
United States Coast and Geodetic Survey, Washington, D. C. 526.9.
United States Commission of Fish and Fisheries, Washington, D. C. 639.
United States Entomological Commission, Department of Agriculture, Washington, D. C. 595.7.
United States Geological Survey, Washington, D. C. 557.3.
United States National Museum, Washington, D. C. 507.
The Anthropological Society, Washington, D. C. 572.
The Library, U. S. Weather Bureau, Department of Agriculture, Washington, D. C. 551.5.
American Monthly Microscopical Journal, Washington, D. C. 578.
United States Military Academy, West Point, N. Y. 378.
Williams College, Williamstown, Mass. 378.

Dominion of Canada.

The Nova Scotian Institute of Natural Science, Halifax, N. S. 506.11.
Queen's College and University, Kingston, Ont. 378.
The Hamilton Association, Hamilton, Ontario. 506.11.

The Canadian Entomologist, London, Ont. 595.7.
The Natural History Society of Montreal, Montreal. 506.11.
McGill College and University, Montreal. 378.
The Royal Society of Canada, Ottawa. 506.11.
The Geological and Natural History Survey of Canada, Ottawa. 557.1.
The Ottawa Field Naturalists' Club, Normal School, Ottawa. 506.11.
Literary and Historical Society, Quebec. 506.11.
The University of Toronto, Toronto, Ont. 378.
The Canadian Institute of Toronto, Toronto, Ont. 506.11.
The Entomological Society of Ontario, Toronto, Ont. 595.7.
Natural History Society, Toronto, Ont. 506.11.
Le Naturaliste Canadien, Cap Rouge, Quebec. 505.
Natural History Society of New Brunswick, St. John, N. B. 506.11.
The Historical and Scientific Association, Winnipeg, Manitoba. 506.11.

Central America and the West Indies.

El Museo Nacional de Mexico, Mexico. 507.
La Sociedad Mexicana de Historia Natural, Museo Nacional, Mexico. 506.12.
El Secretario de Fomento Colonizacion Industria y Comercio, Mexico. 600.
Sociedad de Geografia y Estadistica, Mexico. 910.6.
Sociedad Cientifica "Antonio Alzate" Mexico. 506.12.
Observatorio Astronomico Nacional, Tacubaya, Mex. 522.1.
Museo Nacional de Costa Rica, San José, Costa Rica. 507.
Scientific Association of Trinidad, Trinidad, W. I. 506.12.

South America.

National Observatory, Rio Janeiro, Brazil. 522.1.
Museo Nacional de Buenos Aires, Buenos Aires, Argentina. 507.

Jardin Botanique, Rio Janeiro, Brazil. 580.7.
La Academia Nacional de Ciencias en Cordoba, Buenos Aires, Argentina. 506.13.
La Revista Argentina de Ciencias Medicas, Buenos Aires, Argentina. 610.
El Museo Nacional de Rio de Janeiro, Rio Janeiro, Brazil. 507.
La Société Scientifique du Chile, Santiago, Chile. 506.13.

Europe.

Great Britain and Ireland.

The Belfast Naturalists' Field Club, Belfast, Ireland. 506.22.
The Chemico-Agricultural Society of Ulster, Belfast, Ireland. 630.6.
The Belfast Natural History and Philosophical Society, Belfast. 506.22.
The Birmingham Natural History and Microscopical Society,
The Mason College, Birmingham, England. 506.2.
The Birmingham and Midland Institute, Archæological Section, Birmingham, England. 506.2.
The Bristol Museum and Library, Queen's Road, Bristol, Eng. 507.
The Mining Association and Institute of Cornwall, Tuckingmill, Camborn, England. 620.6.
The Cambridge Philosophical Society, Cambridge, England. 506.2.
The Royal Dublin Society, Dublin, Ireland. 506.22.
The Royal Geological Society of Ireland, Dublin, Ireland. 550.6.
The Dumfriesshire and Galloway Scientific, Natural History and Antiquarian Society, Dumfries, Scotland. 506.21.
The Royal Physical Society, Edinburgh, Scotland. 530.6.
The Fishery Board for Scotland, Edinburgh, Scotland. 639.
The Scottish Meteorological Society, Edinburgh, Scotland. 551.5.
The Edinburgh Botanical Society, Edinburgh, Scotland. 580.6.
The Royal Observatory, Edinburgh, Scotland. 522.1.
The Edinburgh Geological Society, Edinburgh, Scotland. 550.6.

The Royal Cornwall Polytechnic Society, Falmouth, England. 606.

The Folkestone Natural History Society, Folkestone, England. 506.2.

The Geological Society of Glasgow, Glasgow, Scotland. 550.6.

The Natural History Society, Glasgow, Scotland. 506.21.

The Philosophical Society of Glasgow, Glasgow, Scotland. 506.21.

The Yorkshire Geological and Polytechnic Society, Clevinedge, Halifax, England. 550.6.

The Hertfordshire Natural History Society and Field Club, Hertford, England. 506.2.

The Liverpool Geological Society, Liverpool, England. 550.6.

The Liverpool Polytechnic Society, Liverpool, England. 606.

The Literary and Philosophical Society, Liverpool, England. 506.2.

The Geological Survey of Great Britain, 27 Jermyn St., London. 557.942.

The Royal Meteorological Society, London, England. 551.5.

The British Association for the Advancement of Science, London, England. 506.2.

The British Museum, London, England. 507.

The Royal Institute of Great Britain, London, England. 506.2.

The Geological Society, London, England. 550.6.

The Linnæan Society, London, England. 580.6. (Botany.) 590.6. (Zoology.)

The Royal Microscopical Society, London, England. 578.

The Royal Society of London, London, England. 506.2.

The Society of Arts, London, England. 506.2.

The Zoological Society of London, London, England. 590.6.

The Iron and Steel Institute, London, England. 669.

The Museum and Public Library, Maidstone, England. 027.

The Manchester Literary and Philosophical Society, Manchester, England. 506.2.

The Manchester Microscopical Society, Care Hon. Sec. George Wilks, 27 Wynford St. Weaste, Manchester, England. 578.

The Natural History Society of Northumberland, Durham and Newcastle upon Tyne, Newcastle on Tyne, England. 506.2.

The North of England Institute of Mining and Mechanical Engineers, Newcastle on Tyne, England. 620.6.

The Radcliffe Observatory, Oxford, England. 522.1.

The Penzance Natural History and Antiquarian Society, Penzance, England, 506.2.

The Royal Geological Society, Penzance, England. 550.6.

The Plymouth Institution and Devon and Cornwall Natural History Society, Plymouth, England. 506.2.

Stonyhurst College Observatory, Stonyhurst, England. 522.1.

The Royal Institution of Cornwall, Truro, England. 506.2.

The Museum, York, England. 507.

The Yorkshire Philosophical Society, York, England. 506.2.

Germany.

Die Naturforschende Gesellschaft des Osterlandes zu Altenburg, Altenburg. 506.3

Der Naturhistorische Verein für Schwaben und Neuberg. Augsburg. 506.3.

Die Naturforschende Gesellschaft in Bamberg, Bamberg. 506.3.

Die Deutsche Geologische Gesellschaft, Berlin. 550.6.

Der Entomologische Verein in Berlin, Berlin. 595.7.

Der Königliche Preussische Academie der Wissenschaften zu Berlin, Berlin. 506.3.

Der Verein zur Beförderung des Gartenbaues in den Königlichen Preussischen Staaten, Berlin. 580.6.

Der Botanische Verein der Provinz Brandenburg, Berlin. 580.6.

Das Königlichen Geodatischen Institut, Berlin. 526.

Die Physiologische Gesellschaft zu Berlin. 612.

Die Gesellschaft für Erdkunde, Berlin. 550.6.

Die Deutsche Gesellschaft für öffentliche Gesundheitspflege, Berlin. 910.

Die Centralbureau der Internationalen Erdmessung, Berlin. 526.

Das Königlichen Preussichen Metrologischen Institut, Berlin. 389.

Die Königliche Preussische Geologische Landesanstalt und Berg-Academie, Berlin. 550.6.

Die Pbysikalische Gesellschaft, Berlin. 506.3.

Der Naturhistorische Verein der Preussischen Rheinlände und Westphalens, Bonn. 506.3.

Der Verein für Naturwissenschaft zu Braunschweig, Braunschweig. 506.3.

Jahresbericht über die Fortschritte der Chemie, herausgegeben von F. Fittica, Braunschweig. 540.5.

Der Naturwissenschaftliche Verein zu Bremen, Bremen. 506.3.

Der Verein für Hessische Geschichte und Landeskunde in Kassel, Kassel. 506.3.

Die Technische Staatslehranstalt zu Chemnitz, Chemnitz. 606.

Die Naturwissenschaftliche Gesellschaft zu Chemnitz, Chemnitz. 506.3.

Die Naturforschende Gesellschaft in Danzig, Danzig. 506.3.

Der Verein für Erdkunde und verwandte Wissenschaften, Darmstadt. 506.3.

Die Naturwissenschaftliche Gesellschaft Isis in Dresden. 506.3.

Das Königliche Mineralogische Museum, Dresden. 549.07.

Der Verein für Erdkunde, Dresden. 550.6.

Die Naturforschende Gesellschaft, Emden. 506.3.

Die Physikalisch-Medicinische Societät, Erlangen. 506.3.

Die Senkenbergische Naturforschende Gesellschaft, Frankfurt am Main. 506.3.

Der Naturwissenschaftliche Verein des Reg.-Bezirks Frankfurt a. O. 506.3.

Societatum Litteræ, Frankfurt a. O. 506.3.

Die Naturforschende Gesellschaft zu Freiburg in Baden, Freiburg. 506.3.

Die Oberhessische Gesellschaft für Natur- und Heilkunde, Giessen. 506.3.

Die Naturforschende Gesellschaft zu Görlitz, Görlitz. 506.3.

Der Naturwissenschaftliche Verein von Neu-Vorpommen und Rügen zu Greifswald. 506.3.

Die Geographische Gesellschaft, Greifswald. 910.6.

Der Verein der Freunde der Naturgeschichte in Mecklenburg, Gustrow. 506.3.

Die Kaiserliche Leopoldino-Carolinische Deutsche Academie der Naturforscher, Halle a. S. 506.3.

Die Naturforschende Gesellschaft zu Halle a. S. 506.3.

Der Naturwissenschaftliche Verein für Sachsen und Thüringen, Halle a. S. 506.3.

Das Naturhistoriches Museum zu Hamburg, Hamburg. 507.

Der Naturwissenschaftliche Verein in Hamburg, Hamburg. 506.3.

Die Geographische Gesellschaft in Hamburg, Hamburg. 910.6.

Die Wetterauische Gesellschaft für gesammter Naturkunde, Hanau. 506.1.

Die Naturhistorische Gesellschaft zu Hannover, Hanover. 506.3.

Der Naturhistorische Medicinische Verein, Heidelberg. 506.3.

Der Naturwissenschaftliche Verein für Schleswig-Holstein, Kiel. 506.3.

Die Königliche physikalisch-ökonomische Gesellschaft zu Königsberg, Königsberg. 506.3.

Der Verein für Erdkunde, Leipzig. 506.3.

Die Fürstliche Jablonowski'sche Gesellschaft der Wissenschaften, Leipsic. 506.3.

Die Königlich-Sächsische Gesellschaft der Wissenschaften zu Leipzig, Leipsic. 506.3.

Das Naturhistorichen Museum in Lübeck, Lübeck. 507.

Der Naturwissenschaftliche Verein für Lüneberg, Lüneberg. 506.3.

Practische Physik, Dr. Martin Krieg, Redacteur, Magdeburg. 530.5.

La Société d'Histoire Naturelle du Départment de La Moselle, Metz. 506.3.

Der Verein für Erdkunde zu Metz, Metz. 506.3.

Der Naturwissenschaftliche Verein in Magdeburg, Magdeburg. 506.3.

Die Königliche Bayerische Akademie der Wissenschaften zu München, Munich. 506.3.

Die Königliche Sternwarte, Bogenhausen bei München, Munich. 520.6.

Der Westfälische Provinzial-Verein für Wissenschaft und Kunst, Münster. 506.3.

Die Naturhistorische Gesellschaft zu Nürnberg, Nuremberg. 506.3.

Die Deutsche Anthropologische Gesellschaft, Nuremburg. 571.

Der Offenbacher Verein für Naturkunde, Offenbach a. M. 506.3.

Der Naturwissenschaftliche Verein zu Osnabrück, Osnabruck. 506.3.

Der Naturwissenschaftliche Verein in Regensburg, Regensburg. 506.3.

Der Verein für Erdkunde, Stettin. 506.3.

Der Entomologische Verein, Stettin. 595.7.

Der Verein für Vaterländische Naturkunde in Würtemberg, Stuttgart. 506.3.

Der Nassauische Verein für Naturkunde, Wiesbaden. 506.3.

Die Physisch-medic. Gesellschaft zu Würzburg, Wurzburg. 506.3.

Austria and Hungary.

Der Naturforschende Verein in Brünn, Brünn. 506.31.

Regia Societas Scientiarum Natur. Hungarica, Buda-Pest. 506.31.

Die K. Ungarische Geologische Anstalt, Buda-Pest. 550.6.

Der Siebenbürgische Museum Verein, Klausenburg. 507.

Der Ungarische Karpathen Verein, Locse. 506.31.

Die Königliche Böhmische Gesellschaft der Wissenschaften in Prag, Prague. 506.31.

The Hungarian Archeological Society. 572.

Kaiserliche Akademie der Wissenschaften, Vienna. 506.31.

Die Kaiserlich-Königliche geographische Gesellschaft in Wien, Vienna. 910.6.

Das K. K. Naturhistorische Hof-Museum, Vienna. 507.

Die Kaiserlich-Königliche Zoologisch-Botanische Gesellschaft in Wien, Vienna. 570.6.

Kaiserlich-Königliche Geologische Reichsanstalt, Vienna. 550.6.

Der Naturwissenschaftliche Verein an der Universität zu Wien, Vienna. 506.31.

Die K. K. Central-Anstalt für Meteorologie und Erdmagnetismus, Vienna. 551.5.

Société Archéologique Croate au Musée National, Zagreb. 572.

France.

La Société des Sciences Historiques et Naturelles de l'Yonne, Auxerre. 506.4.

La Société Médicale de l'Yonne, Auxerre. 610.6.

Le Commission Météorologique de la Gironde, Bordeaux. 551.5.

La Société Linnéenne de Bordeaux, Bordeaux. 506.4.

La Société des Sciences Physiques et Naturelles de Bordeaux, Bordeaux. 506.4.

Laboratoire de Géologie de la Faculté des Sciences de Caen, Caen. 550.7.

L'Académie Nationale des Sciences, Arts, et Belles-Lettres de Caen, Caen. 506.4.

La Société Nationale des Sciences Naturelles, Cherbourg. 506.4.

La Société Linnéenne de Normandie, Caen. 506.4.

La Société de Borda, Dax. 506.4.

L'Académie des Sciences, Arts et Belles-Lettres de Dijon, Dijon. 506.4.

L'Union Géographique du Nord de la France, Douai. 910.6.

La Société Philotechnique du Maine, Le Mans. 506.4.

La Société Géologique du Nord, Lille. 550.6.

L'Académie des Sciences, Belles Lettres, et Arts de Lyon, Lyons. 506.4.

La Société Linnéenne de Lyon, Lyons. 506.4.

La Société d'Agriculture, Histoire Naturelle, et Arts Utiles de Lyon, Lyons. 506.4.

La Société des Sciences Industrielles de Lyon, Lyons. 606.

La Société Botanique de Lyon, Lyons. 580.6.
La Société des Sciences de Nancy, Nancy. 506.4.
L'Académie des Sciences et Lettres de Montpellier, Montpellier. 506.4.
L'Académie de Stanislas, Nancy. 506.4.
L'Ecole Polytechnique, Paris. 378.
L'Observatoire de Paris, Paris. 522.1.
L'Académie de Médecine, Paris. 610.
L'Ecole Nationale des Mines, M. Dunod, Editeur, 47 Quai des Augustins, Paris. 622.
L'Académie des Sciences de l'Institut de France, Paris. 610.
La Société National d'Agriculture de France, Paris. 630.6.
Le Journal de Micrographie, Paris. 578.
Le Muséum d'Histoire Naturelle, Paris. 507.
Le Naturaliste, Paris, 590.5.
La Société Entomologique de France, Paris. 595.7.
La Société Géologique de France, Paris. 550.6.
La Société Zoologique de France, Paris. 590.6.
La Société des Amis des Sciences Naturelles de Rouen, Rouen. 506.4.
La Société de l'Industrie Minérale, St. Etienne. 622.6.
L'Académie de Sciences, Inscriptions et Belles-Lettres de Toulouse, Toulouse. 506.4.
La Société d'Histoire Naturelle de Toulouse, Toulouse. 506.4.
Laboratoire de Zoologie, Villefranche-sur-Mer. 590.7.

Belgium.

La Société d'Etudes Scientifiques d'Anvers, Antwerp. 506.41.
L'Observatoire royal de Bruxelles, Brussels. 522.1.
La Société Belge de Géologie, Brussels. 550.6.
L'Académie royale des Sciences, des Lettres et des Beaux-arts de Belgique à Bruxelles, Brussels. 506.41.
La Société Belge de Microscopie, Brussels. 578.
La Société Entomologique de Belgique, Brussels. 595.7.

La Société royale Malacologique de Belgique, Brussels. 594.
La Société Géologique de Belgique, Liége. 550.6.
La Société royale des Sciences de Liége, Liége. 506.41.
La Revue Universelle des Mines, Liége. 622.

Italy.

Società Italiana dei Microscopisti, Acireale. 578.
Reggia Accademia Petrarca di Scienze, Lettere ed Arti in Arezzo, Arezzo. 506.5.
Accademia delle Scienze dell' Istituto di Bologna, Bologna. 506.5.
Accademia Gioenia di Scienze naturali in Catania, Catania. 506.5.
Reale Istituto di Studi superiori pratici e di Perfezionamento, Firenze. 610.
Regio Istituto tecnico superiore, Milan. 606.
Società Meteorologica Italiana, Moncalieri. 551.5.
Reale Accademia delle Scienze fisiche e matematiche di Napoli, Naples. 506.5.
Reale Osservatorio, Palermo. 522.1.
Reale Accademia di Scienze, Lettere, e Belle Arti di Palermo. 506.5.
Accademia Medico Chirugica, Perugia. 610.
Reale Istituto lombardo di Scienze e Lettere, Pisa. 506.5.
La Società toscana di Scienze naturali, Pisa. 506.5.
Società degli Spettroscopisti Italiani, Rome. 522.67.
Reale Accademia dei Lincei, Rome. 506.5.
Reale Comitato geologico d'Italia, Rome. 550.6.
Specula Vaticana, F. Francis Denza, Rome. 506.5.
Rassegna delle Scienze Geologiche, Rome. 550.5.
Società fra i Cultori delle Scienze mediche, Sienna. 610.
R. Accademia Fisiocritici, Sienna. 506.5.
Musei di Zoologia ed Anatomia comparata della regia Università di Torino, Turin. 507.
Bolletino, Dell 'Osservatorio Centrale, Turin. 522.1.

Osservatorio della Reggia Università di Torino, Turin. 522.1.
Reale Accademia delle Scienze di Torino, Turin. 506.5.
Reale Istituto tecnico Antonio Zanon in Udine, Udina. 506.5.
Reale Istituto Veneto di Scienze, Lettere, ed Arti, Venice. 506.5.
L'Ataneo Veneto, Venice. 506.5.
Curco Museo e Raccolta Corver in Venezia, Venice. 507.

Spain.

Real Academia de Ciencias, Madrid. 506.6.

Portugal.

Jornal de Sciencias, Coimbra. 505.
Seccao dos Trabalhos geologicos de Portugal, Lisbon. 550.6.
Sociedade de Geographia, Lisbon. 910.6.
Academia Real das Sciencias, Lisbon. 506.61.

Russia.

Die Naturforscher Gesellschaft der Universität, Dorpat. 506.7.
Die Gelehrte estnische Gesellschaft zu Dorpat, Dorpat. 506.7.
Société ouralienne d'Amateurs des Sciences naturelles, Ekatherinberg, Russia. 506.7.
La Société des Naturalistes attachée à L'Université Impérial St. Wladimir à Kiew, Kiev, Russia. 506.7.
L'Académie des Sciences de Cracovie, Krakow. 506.7.
La Société impériale des Naturalistes de Moscou, Moscow. 506.7.
Der Naturforscher-Verein zu Riga, Riga. 506.7.
Académie impériale des Sciences de St. Pétersbourg, St. Petersburg. 506.7.
Jardin impériale de Botanique, St. Petersburg. 580.6.
Comité géologique, de la Russie, St. Petersburg. 550.6.
Societas entomologica rossica, St. Petersburg. 595.7.
La Société physico-chimique russe à l'Université de St. Pétersbourg, St. Petersburg. 530.6.

Norway.

Bergens Museum, Bergen, Norway. 507.
Den norske Gradmalings-Komission, Christiania. 510.
Den norske Nordhaus-Expedition, Christiania. 590.6.
Videnskabs-Selskabet, Christiania. 506.8.
L'Institut météorologique de Norvège, Christiania. 551.5.
International Polarforschung, Christiania. 500.
Det kongelige norske Videnskabernes, Drontheim. 506.8.
Tromso Museum, Tromso. 507.

Sweden.

Societas pro Flora et Fauna Fennica, Helsingfors. 506.81.
Geologiska Undersökning Finlands, Helsingfors. 550.6.
Kongliga Universitet, Lund, Sweden. 378.
Entomologisk Tidskrift, Stockholm. 595.7.
Institut royal géologique de la Suède, Stockholm. 550.6.
Kongliga svenska Vetenskaps-Akademien, Stockholm. 506.81.
Geologiska Föreningen i Stockholm, Stockholm. 550.6.
Entomologiska Föreningen, 94 Drottninggatan, Stockholm. 595.7.
Kongliga Vetenskaps Societeten, Upsala. 506.81.

Denmark.

Det Kongelige danske Videnskabernes Selskab i Kjöbenhavn, Copenhagen. 506.82.
Naturhistoriske Forening i Kjöbenhavn, Copenhagen. 506.82.

Switzerland.

Die naturforschende Gesellschaft, Basel. 506.9.
Die naturforschende Gesellschaft in Bern, Berne. 506.9.
Thurgauische naturforschende Gesellschaft, Frauenfeld. 506.9.
La Société helvétique des Naturalistes, Freiburg. 506.9.
La Société fribourgeoise des Sciences naturelles, Freiburg. 506.9.
M. H. de Saussure, Geneva.

Société de Physique et d'Histoire naturelle de Genève, Geneva. 506.9.

Institut national génévois, Geneva. 506.9.

Société vaudoise des Sciences naturelles, Lausanne. 506.9.

Schweizerische naturforschende Gesellschaft in Luzern, Luzerne. 506.9.

Société des Sciences naturelles de Neuchatel, Neuchatel. 506.9.

St. Gallische naturwissenschaftliche Gesellschaft, St. Gall. 506.9.

Die Naturforschende Gesellschaft in Solothurn, Solothurn. 506.9.

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