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ERRATA.

p. 67. Next to last paragraph should read, "The paper appears in the Trans. Amer. Soc. Civ. Eng. XXXIII. 235."

p. 76. 3d line from bottom should read, "The first paper was by Prof. William Hallock upon," etc.

p. 102. Next to last paragraph, 2d line, "has" not "have."

p. 109. 1st line should read, "conditions resulted in the."

p. 109. 2d paragraph, last line should read "of this group, the Foraminifera."

p. 110. 7th line, after "b" insert "Assise 2."

p. 111. After "GLOBIGERINA GRANDIS n. sp. Pl. I., fig. 6," insert "This species is closely related to the preceding, but is larger, the final chamber being especially large. It was composed of four chambers, of which the first three are arranged lineally or nearly so."

p. 115. 1st paragraph, last line, delide "inner." After "value," add "on the under side."

p. 126. 11th line delide "Band."

p. 148. Under Brachiopoda, after Obolella nitida, Ford, insert (?). Also in description of Pl. II., fig. 8, insert (?) after Obolella nitida, Ford.

p. 251. 8th line "CORACO-EPITROCHLEARIS" not "EPITROCHLARIS."

Plate XIX. Description, 1st and 2d lines, "humerus" not "humorus."

TRANSACTIONS

OF THE

NEW YORK ACADEMY OF SCIENCES.

REGULAR BUSINESS MEETING.

October 1st, 1894.

The meeting was called to order by President Rees, fourteen persons being present.

The minutes of the last meeting were read and approved.

The Secretary presented the following nominations for resident membership: Mr. John Jacob Astor, Mr. J. C. Pfister, and on motion they were referred to the Council.

The Secretary presented the name of Prof. Bohuslav Brauner, Ph. D., of Prague, Bohemia, as a corresponding member, and on motion the nomination was referred to the Council.

The following paper, which had been transmitted to the Academy through Dr. H. Carrington Bolton, was then read.

ON FLUOPLUMBATES.

BY BOHUSLAV BRAUNER, PH. D., PROFESSOR OF CHEMISTRY IN THE BOHEMIAN UNIVERSITY, PRAGUE.

I beg to lay before the Academy a short account of a new series of salts of tetratomic lead, a work which was begun in the Owens College, Manchester, in 1881, and which at intervals has occupied my attention several years.

The first member of the series of *fluoplumbates*, derivatives of fluoplumbic acid, is the potassium salt described below; it has been obtained by the following methods:

1. By treating the freshly precipitated oxide $Pb_5O_7,3H_2O$ which was first described by me in 1885 (Royal Society of Bohemia 295–299), as the intermediate compound between Pb_2O_3 and Pb_3O_4, with hydrofluoric acid and potassium hydrogen fluoride. A mixture of lead fluoride and the crystalline fluoplumbate is obtained, the latter being separated from the former by recrystallization from hydrofluoric acid.

2. By substituting fluorine for oxygen in Fremy's potassium plumbate, the crude salt containing potassium and lead dioxide in the proportion of $3K_2O : PbO_2$ is dissolved in hydrofluoric acid, and from the filtered liquid crystals separate out, which, if necessary, may be purified by recrystallization from hydrofluoric acid.

3. By dissolving lead tetra-acetate $Pb(C_2H_3O_2)_4$ in hydrofluoric acid containing acid potassium fluoride. On spontaneous evaporation of the solution, needle shaped crystals of the fluoplumbate are obtained.

The salt has the composition: $3KF.HF.PbF_4$, being tripotassium-monohydrogen orthofluoplumbate, as proved by the following analytical data.

Calculated for $3KF.HF.PbF_4$.			Found.				
			I.	II.	III.	IV.	V.
3K	117·42	24·60	24·57	—	24·53	—	—
Pb	206·9	43·35	43.41	43·36	43·35	—	—
8F	152·0	31·84	—	31.23	—	31.65	—
H	1·0	0·21	—	—	—	—	0.22
	477·32	100·00					

The analysis shows that the substance contains no oxygen. The crystallographic examination of the salt was, in so far of theoretical interest, as Marignac has described a perfectly analogous compound of quadrivalent tin, namely $3KF.HF.SnF_4$, for it shows that both salts are isomorphous. The crystals were examined by Prof. Ch. Vrba of our University, but unfortunately their faces are uneven and corroded, so that no absolutely exact crystallographic and optical examination could be made. Assuming the monoclinic symmetry as has been assumed by Marignac for the fluostannate, the elements are approximately:

a : b : c = 0·6223 : 1 : 0·4818 and β = 86° 41′. The forms observed are: m (110) ∞P; b (010) ∞P$\grave{\infty}$; p ($11\bar{1}$) — P; π (111) P; the same forms have been observed by Marignac and in addition to them c (001) oP was found by him. The angles calculated from the above axial relations for the normals of the planes are given below together with the inclinations observed and Marignac's values of the analogous fluostannate are appended for comparison:

		Calculated.	Found.	Marignac for 3 KF. HF. Sn F_4.
m (110):	m′ ($1\bar{1}0$)	63° 42′	63° 39′	64° 8′
	b (010)	——	*58 9	57 54
	p (111)	——	*46 7	——
p (111):	p′ ($1\bar{1}1$)	——	40 37	40 49
:	b (010)	69 41	69 45	——
π ($11\bar{1}$):	π' ($\bar{1}11$)	42 45	41 15	43 12
:	b (010)	68 37	69 31	——

The salt is stable in dry air but turns brown in moist air, being decomposed by water in the following manner: 3KF. HF. $PbF_4+nH_2O=PbO.H_2O+3KF.HF+HF+(n-3)H_2O$.

The reaction is reversible, for the hydrated dioxide separated first is dissolved by hydrofluoric acid and acid potassium fluoride, and consequently complete decomposition takes place only in presence of a large quantity of water.

The above reaction was used only for the analysis of the salt. It was also proved that on decomposition with water, 5 mols. HF are set free, for 100 pts. of the salt yielded in this way 20·77 pts. HF. instead of the calculated quantity of 20·95 pts. HF.

The weight of the salt remains absolutely constant even when heated at 100–100° for many hours. At 200° hydrogen fluoride begins to escape, the loss amounting to 1·72 p. c. At 250° the loss was 5·43 p. c., showing that 1·24 p. c. of the total of 7.96 p. c. of the available quantity of "active" fluoride has been given off.

In order to study the behaviour of the salt at a higher temperature some of the salt was placed in a small platinum tube closed at one end and dried for several hours at 230–250.° The closed end of the tube was heated then with a Bunsen flame. Long before the tube became red hot a gas began to be evolved having the characteristic odour of fluorine and liberating iodine in crystals from potassium iodide paper held at the exit of the gas. Fumes of hydrofluoric acid issued from the nose after inhaling and exhaling the gas. Some small crystals of silicon were placed in the open end of the tube, and when the closed end of the tube was heated the silicon burnt with vivid incandescence and even with explosive violence (Moissan's test for fluorine). The residue is white or slightly yellow but care must be taken to exclude moisture, for when water vapour comes into contact with the heated salt, hardly any fluorine is given off, and a brown deliquescent residue is left.

This experiment has been repeated several times, and it confirms the accuracy of the results obtained by me 13 years ago, viz.: that fluorine may be obtained on heating some higher fluorides. Although Moissan has since then obtained free fluorine by a *physical* method, we have here the first trustworthy *chemical* process of obtaining this gas. If potassium fluoplumbate loses its hydrogen fluoride at about 230° without losing more than traces of fluorine, one gram of the salt should yield on heating 47 c. c. of fluorine which could be freed from any hydrogen fluoride present by passing it over potassium fluoride, according to Moissan.

Qualitative experiments have shown that a whole series of *fluoplumbates* exist, the metals forming them being the same as those in Marignac's series of fluostannates, but unfortunately the work is connected with great experimental difficulties, for some of the salts are decomposed by moisture as soon as they are taken out of the mother liquor.

FLUOPLUMBIC ACID AND LEAD TETRAFLUORIDE.

Fluoplumbic acid is obtained either on dissolving some forms of hydrated lead dioxide in hydrofluoric acid or on dissolving lead tetra-acetate in strong hydrofluoric acid, acetic acid being liberated in this case, for on adding soluble fluorides to this solution it gives the corresponding fluoplumbates. This solution, however, cannot be evaporated to dryness, even at the ordinary temperature, a crust of the brown lead dioxide being deposited.

In order to prepare anhydrous *lead tetrafluoride* potassium fluoplumbate was reduced to a fine powder in a platinum basin, using a small platinum crucible as a pestle; a dry agate mortar cannot be used, for in contact with silica the salt gives silicon tetrafloride, water being formed which at once decomposes the salt. The powdered salt (0.874 grm.) was then thrown on the surface of cold, concentrated sulphuric acid (5 cc.). Hydrogen fluoride at once escapes and a pale yellow solution is obtained, having the same characteristic color as that of lead tetrachloride, which was isolated by Friedrich in this laboratory. Dense fumes soon begin to come off, having an extremely pungent smell which resembles that of free fluorine. They seem to contain some gaseous lead tetrafluoride. After the salt has completely dissolved in the acid: $3KF.HF.PbF_4+3H_2SO_4=4HF+3KHSO_4+PbF_4$, the clear yellow liquid begins to get turbid, and after half an hour or so it is converted into a thick lemon-yellow jelly. From this emulsion, which probably contains the collodial modification of lead tetrafluoride, the latter cannot be separated at the ordinary temperature. On heating the mass to 100°, some hydrofluoric acid escapes, and a heavy, lemon-yellow powder is deposited on the bottom of the crucible, this probably being another modification of lead tetrafluoride. The sulphuric acid could be easily poured off from the yellow precipitate, and it was found that the acid contains no lead in solution.

The yellow powder could be washed with sulphuric acid by decantation, and no apparent change took place on heating the mixture to 100°. But as soon as it was heated to 115°, complete decomposition took place and white lead sulphate was left at the bottom of crucible: $PbF_4+H_2SO_4=PbSO_4+2HF+F_2$(?).

I have not yet been able to isolate lead tetrafluoride, in spite of numerous attempts, as no liquid could be found which would displace the sulphuric acid without at the same time decomposing the tetrafluoride. Dry plates of plaster of Paris absorb the greater part of the acid, but not all, and after some time decomposition takes place and the brown dioxide is formed: $PbF_4+2H_2O=PbO_2+4HF$. Hydrofluoric acid dissolves it partly and the solution contains fluoplumbic acid, for it liberates iodine from potassium iodide, etc.

On comparing the properties of the incompletely studied lead tetrafluoride with those of lead tetrachloride, which I often had an opportunity of observing, as it was discovered by Friedrich in this laboratory, it will be seen that both substances are set free from their double salts by strong sulphuric acid, without being decomposed by it. The tetrachloride is a liquid, whilst the tetrafluoride seems to exist in several forms. I hope to be able to throw some light on the tetrafluoride of lead by a comparative study of the anhydrous tetrafluoride of tin.

LEAD DISULPHATE.

Potassium fluoplumbate was dissolved in a very large excess of cold sulphuric acid so that even after several days no separation of tetrafluoride took place. The clear, yellow liquid gave off dense fumes, smelling of fluorine, in large quantity. The solution was heated for several days in a covered crucible on the water bath, then allowed to stand in a dessicator and heated again, and this alternative process was repeated during several weeks. The solution was found to give off a smell of hydrofluoric acid and an orange-yellow crystalline substance was separated slowly, but only after standing for about two months the solution became colourless and free from any dissolved tetrafluoride. After this time the solid orange-coloured substance was washed with sulphuric acid by decantation. The acid was then poured off as completely as possible and the substance was decomposed with water, when it yielded lead dioxide and a solution containing sulphuric acid but only a small quantity of hydrofluoric acid. The substance can be therefore only lead disulphate $Pb\ (SO_4)_2$, analogous to $Sn\ (SO_4)_2$ and the formation requiring a very long time, must have taken place according to the following equation:

$$PbF_4 + nH_2SO_4 = Pb(SO_4)_2 + 4\ HF + (n-2)H_2SO_4.$$

The more the *quadrivalent* lead is studied, the greater becomes its analogy with *quadrivalent* tin and of course the existence of the substances described in the present paper gives additional confirmation to the position which lead occupies in Mendelejeff's periodic system. Thirty years ago hardly anyone could have predicted that lead would form compounds analogous not only with those of tin, but also with those of silicon, titanium, ziconium, cerium and thorium.

May, 1894.

Prof. Hubbard exhibited some gnawed beaver sticks from the pond described by him last year (Trans., Vol. XIII., 115, 177) and commented upon them.

Reports of summer work were then presented by the following members: Osborn, Britton, Martin, Hallock, van Ingen, Kemp, Cox, Pupin and Rees, after which the Academy adjourned.

J. F. Kemp,
Recording Secretary.

Stated Meeting.

October 8th, 1894.

The Section of Astronomy and Physics organized immediately with President Rees in the chair, and thirteen members and guests present.

At the suggestion of President Rees, Prof. Mayer of Stevens Institute made a few remarks upon his summer experiences, especially in England at the meeting of the British Association for the Advancement of Science. He spoke quite fully of the discovery by Lord Rayleigh of a new substance in the air; its preparation by two methods, and its properties.

Remarks upon the subject were made by President Rees and Capt. Casey.

The first paper of the evening was by President Rees, "Remarks on the Observations for Variations of Latitude made at Columbia College and at the Royal Observatory at Naples."

President Rees detailed the preliminaries and negotiations which led to the inception of this work, and the general plans of the observations, as well as the details of manipulating the instruments; giving also the method and principle of the calculations and corrections.

In all about 2400 pairs of stars were observed at each Observatory, during the 14 months covered by the original plan. The observations are, by mutual agreement, to be continued four nights in each two weeks, during the next two or three years.

The calculations are not yet completed, but point to an extreme variation of about $0''.35$ as a first approximation, with a probable error of one evening's work of $0''.07$.

The paper was discussed by Capt. Casey, Prof. Mayer and others.

The second paper was also by President Rees on, "The Measuring Apparatus for Astronomical Photographs, made by Repsold & Sons of Hamburg, and presented to the Columbia College Observatory by Rutherford Stuyvesant, Esq." The apparatus was exhibited and explained, and those interested made a close examination of it beauties and conveniences.

On motion the meeting adjourned.

WM. HALLOCK,
Secretary of Section.

STATED MEETING.

October 15th, 1894.

The Section of Geology and Mineralogy immediately organized. Prof. R. P. Whitfield, Chairman of the Section, presiding.

Fourteen persons present.

The minutes of the last meeting were read and approved.

The first paper of the evening was

DISLOCATIONS IN CERTAIN PORTIONS OF THE ATLANTIC COASTAL PLAIN STRATA AND THEIR PROBABLE CAUSES.

(FIGS. 1–5.)

BY ARTHUR HOLLICK.

The paper was illustrated by charts and diagrams.

GENERAL CONSIDERATIONS.

In the preparation of this paper it was assumed that the following general propositions might be taken for granted:

1. That mountain chains consist principally of sedimentary rocks, originally laid down as deposits along continental borders or inland seas and subsequently crumpled and upheaved by horizontal pressure.

2. That there is a general parallelism and successive formation of ranges in any one region; the successive formation proceeding coastward.

3. That the crumpling takes place along the line of greatest stress or weakness, *i. e.*, along the major axis of the area of deposition.

The question which this paper is designed to present and discuss is what indications are there of crumpling, upheaval, or any other phenomena identical with or simulating mountain making processes in the Atlantic coastal plain region and whether they may be better accounted for on the theory of mountain making as previously outlined, or upon some other hypothesis.

From the character of the material which enters into the composition of the strata forming the coastal plain and from their succession and the organic remains contained in them, we know that there was a transition from fresh or brackish water to marine conditions, and that the area of deposition was probably a shallow syncline or trough, with its major axis practically parallel with the present coast line, that is in a north and south, or somewhat northeast and southwest direction.

With the great vertical fluctuations in level which are recognized as having taken place since the eocene we need not concern ourselves, as they practically affected all parts of the region alike. It is merely in regard to local disturbances, analogous to mountain making processes, that this paper has to do.

PRINCIPAL LINES OF DISTURBANCE, AND THEORIES WHICH HAVE BEEN ADVANCED IN REGARD TO THEM.

Indications of faulting or folding have been mentioned by several observers in the Southern States, notably by W. H. Dall in Florida * and in all the observations the facts point to a system of folding or dislocation in a general north and south direction, as our previous experience would naturally cause us to expect.

Further north, extending from Nantucket and Martha's Vineyard, through Block Island, Gardiner's Island, Long Island, Staten Island and northern New Jersey we find another line or area of disturbance, having a general east and west direction. The facts, however, in connection with this area are so different from those with which we are familiar elsewhere in America, that but for the circumstance of one isolated portion having been utilized by a prominent authority as an example of mountain making forces, it would not have occurred to me to discuss it in such connection. Prof. N. S. Shaler, in his " Report on the

*1. "Notes on the Geology of Florida," Am. Journ. Sci. xxxiv. (1887) 161-170.
2. Bull. No. 84, U. S. G. S., "Correlation Papers—Neocene."

Geology of Martha's Vineyard,"* argues for the hypothesis of mountain making forces in order to account for the distortions of the Cretaceous and Tertiary strata on that island and has further reiterated his views in papers read before the Geological Society of America.†

During the time that Prof. Shaler was engaged in making his investigations on Martha's Vineyard, I had been studying the phenomena of folding and upheaval represented in the coastal plain strata, in connection with the terminal moraine on Staten Island and Long Island, and the conclusion to which I was irresistibly driven was that these phenomena were to be accounted for on the theory of ice action alone, as first suggested by Dr. F. J. H. Merrill.‡ From Prof. Shaler's report I was also led to infer that a like explanation could be applied to the conditions found to exist on Martha's Vineyard, and the opinion expressed by Mr. Warren Upham in this connection § further strengthened the idea. These views were published by me in several papers relating to the geology of the region ‖ and after a subsequent visit to Martha's Vineyard I became convinced of their correctness as applied to that locality also, and published my conclusions to that effect.¶ Further investigations made since then, on Long Island, Staten Island, Gardiner's Island and in northern New Jersey, have brought to light several new facts which seem to strengthen those previously made, and we are now in a position to state, as beyond question, that the line

* Seventh Ann. Rept. U. S. G. S. (1885-86) 297-363.

† 1. "Tertiary and Cretaceous Deposits of Eastern Massachusetts," Bull. Geol. Soc. Am. 1. (1890) 443-452.
2. "Pleistocene Distortions of the Atlantic Coast," *l. c.* v. (1894) 199-202.

‡ 1, "On the Geology of Long Island," Ann. N. Y. Acad. Sci. iii. (1886) 341-364. *Vide* pp, 358, 359, "We find the stratified gravels, sands and clays upheaved by the lateral pressure of the ice sheet and thrown into a series of marked folds at right angles to the line of glacial advance."
2, "On some dynamic effects of the ice sheet," Proc. Am. Assn. Adv. Sci. xxxv. (1886) 228, 229, in describing the morainal ridges of Long Island, Block Island, Martha's Vineyard, etc., he says: "They differ from moraines elsewhere in the fact that there is but little glacial drift on them and their elevation is almost everywhere dependent on the existence of anticlinal folds in the stratified beds which coincide with the morainal ridges. That these folds have been produced by the lateral thrust of the ice sheet we cannot doubt, since their general trend is at right angles to the direction of glacial motion * * * * * and they do not occur south of the southern range of morainal hills."

§ "Marine Shells and Fragments of Shells in the Till near Boston," Am. Journ. Sci. xxxvii. (1889) 359, 372.
Vide p. 370: "To such glacial thrust and uplifting I would attribute likewise the tilted condition of the beds forming the base of Sankoty Head and the elevation of the included layers of shells. More than this, I believe that the same cause will account for the elevation and folding of the wonderful section of steeply inclined Miocene strata which underlie the terminal moraine in Gay Head."

‖ 1. "The Palæontology of the Cretaceous Formation on Staten Island," Trans. N. Y., Acad. Sci. xi. (1892) 96-103.
2. "Plant Distribution as a Factor in the Interpretation of Geological Phenomena, with Special Reference to Long Island and Vicinity," *l. c.*, xii. (1893) 189-202.

¶ "Observations on the Geology and Botany of Martha's Vineyard," *l. c.* xiii. (1893) 8-22.

of disturbance is coincident with the line of the terminal moraine from Nantucket to northern New Jersey; that the phenomena of folding and crumpling in the strata of the coastal plain are only to be found where the moraine has advanced over some portion of the plain; and that these phenomena cease abruptly where the moraine bends away from or finally leaves the plain.

It may perhaps appear unfair to assume that Prof. Shaler, having restricted his studies to Martha's Vineyard,* would extend the theory which he has so ably advocated for that locality, so as to include Long Island and westward. On the other hand the opinions of the observers previously quoted are equally worthy of consideration, and it is certainly within the bounds of fairness that one who has not been restricted to a single locality, but has studied the region as a whole, should be allowed to say that the phenomena are identical from one extremity of the region to the other, and that any theory advanced to account for them in one section must also account for them in every other section. One series of cause and effect has been instrumental throughout,—either mountain making forces, ice action, or some other agency,—and inasmuch as the two mentioned are the only ones which have been advocated we may confine ourselves to a discussion of these, and the relative claims which they have upon our confidence, considering them both on *a priori* grounds and by actual weight of evidence.

DISCUSSION OF FACTS IN CONNECTION WITH THE LINE OF THE TERMINAL MORAINE.

Beginning with Martha's Vineyard we may consider the facts there as types, on a more extended scale, of those elsewhere on the line of the moraine. The island consists essentially of a series of hills on the north, composed of a core of cretaceous and post-cretaceous strata, tilted and folded, flanked on the north and capped on the top by bowlder till, which gradually merges into water assorted material on the southern flanks and extends over the plains beyond. Most of the sections given in Prof. Shaler's papers show this structure admirably and render any further illustration of the locality unnecessary. I have,

***Mem.* Since the above was written, at the Brooklyn meeting of the Geological Society of America, Prof. Shaler was enabled to hear the argument and to briefly discuss it. He stated that he had visited both Staten Island and northern New Jersey, and while admitting the possibility of ice action as the cause of crumpling and other disturbances in the plastic strata in these localities, could not admit its application to Martha's Vineyard on account of his conviction that the topography of these hills had been determined in pre-glacial times.

however, introduced (see Fig. 1) an ideal section to serve as the general type of the morainal structure under discussion, with which these and sections from other localities may be compared. The Gay Head escarpment is unique, however, as it presents the most extensive section of the moraine from base to summit which we have anywhere exposed in the region.

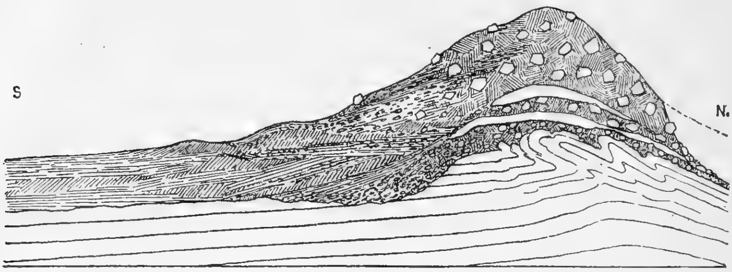

FIG. 1. IDEAL SECTION THROUGH THE TERMINAL MORAINE.

Proceeding westward we find a similar structure to exist on Long Island, although the exposures are far more limited. Nevertheless, at Cold Spring (see Fig. 2), Northport and Glen

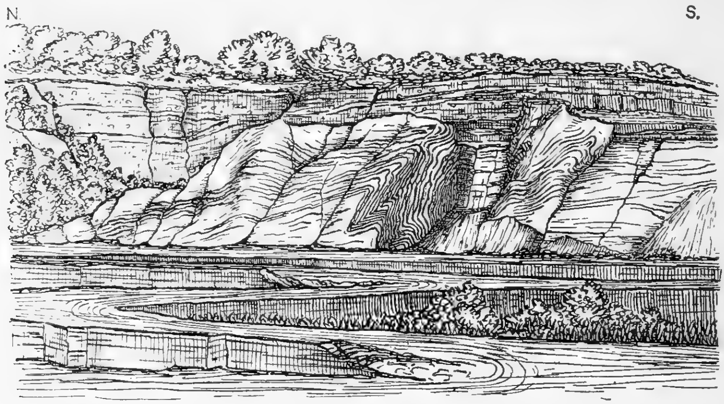

FIG. 2. DISTORTED CLAYS AND SAND, COLD SPRING, LONG ISLAND.

Cove, examples may be seen in miniature, and we have only to imagine Long Island separated into parts, by convenient north and south erosion channels, in order to reproduce indefinitely, Martha's Vineyard, with Gay Head.

On Staten Island the facts are even of greater interest and significance. The moraine crosses a portion of the coastal plain near the Narrows, thence bends northward and rests upon the archæan axis and again enters upon the plain a few miles further west.

I had long been familiar with the fact that beneath this latter portion of the moraine there exists a contorted series of gravels, sands and clays, comparable with those of Long Island, but it was not until about two years ago, when a deep cutting was made for the Staten Island Rapid Transit Railroad, through the moraine near the Narrows, that we were able to demonstrate the existence of a similar structure there.*

At the extreme southwestern end of the Island and in the adjacent portion of New Jersey the evidences of distortion are not so manifest. Instead of violently crumpled folds there is a more undulatory structure to the core upon which the bowlder till rests, as if it had suffered erosion or had been merely squeezed upward in places, the strata often retaining their normal dip and strike, and portions of them are to be seen included in the till, as described by A. Helland† in regard to the brown coal strata at Teutschenthal, near Halle, Saxony, "being sometimes caught up and included *en masse* in the till." In the vicinity of Kreischerville, Staten Island, this phenomenon is specially prominent, particularly where a mass of pure white cretaceous clay is imbedded in the red bowlder till (see Fig. 3) I am inclined to attribute the lack of violent crumpling in this area to the fact that the ice advanced over this portion of the coastal plain from a comparatively level region, and therefore merely eroded it to a limited extent and slid over it, without plowing down to the depths which it did in those regions where it flowed over an escarpment of hard crystalline rock onto the incoherent strata of the plain, as in the case of Long Island Sound and eastward. It is also to be considered that but a very limited area of the coastal plain was reached by the ice in New Jersey and on Staten Island, so that the force of its advance and the weight of its mass must have been far less there than to the north of Long Island and Martha's Vineyard, and the material for erosion much more limited. In other words, the greatest indications of disturbance are to be seen where the ice advanced over the greatest extent of coastal plain area.

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* "Notes on the Geology of the New Railroad Cut at Arrochar." Proc. Nat. Sci. Ass'n. S. I., June 10th, 1893.

† "Ueber die glacialen Bildungen der Nord-Europäischen Ebene," Zeitschr. d. Deutsch. Geol. Gesellsch. xxxi. (1879) 63-106.

In this connection we also have a highly significant series of facts on Staten Island to which attention has not been previously called. In that portion of the coastal plain area near the Narrows, upon which the moraine rests, the underlying strata are folded and tilted exactly as they are on Long Island and Martha's Vineyard. Up to this point the evidences of disturbance have been continuous. As soon, however, as the line of the moraine leaves the plain and bends around over the archæan area all indications of disturbance cease absolutely, and the topography of the plain is as level and uniform as at any locality in New Jersey or on Long Island to the south of furthest ice advancement. Further than this, the signs of disturbance do not reappear until the line of the moraine is again met with on the plain.

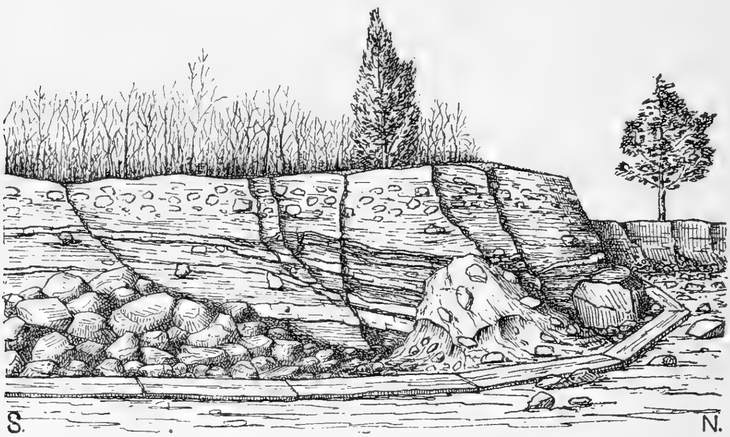

FIG. 3. CRETACEOUS CLAY INCLUDED IN BOWLDER TILL, KREISCHERVILLE, STATEN ISLAND.

Between these two points they are absolutely absent, and yet a glance at the region will convince any observer that had the ice advanced over this portion of the plain the phenomena of crumpled strata would have been continuous from one extremity of Staten Island to the other. This one little break seems to have been specially preserved as an object lesson in this connection.

If there are any evidences of crumpling or folding in an east and west direction in connection with the moraine west of the coastal plain in New Jersey, or in the plain south of the moraine, I have yet to see them. Dr. N. L. Britton has mentioned to me the existence of a small but well marked fold, involving a displacement of two or three feet, in clay strata on the road between Sayerville and New Brunswick, but I failed to find it, after a trip to the locality with that special object in view. It may also perhaps be pertinent to remark in this connection that a phenomenon which simulates the folding of plastic strata may often be seen where gneissic rock has decayed in place, but the two phenomena would not be confounded by anyone who had seen and studied both.

As to the dip and strike of the disturbed strata, in the few localities where observations have been possible, I am forced to admit that they are too erratic to be of much stratagraphic value. They vary in the most eccentric manner, but there is a prevailing strike coinciding with the trend of the moraine, and

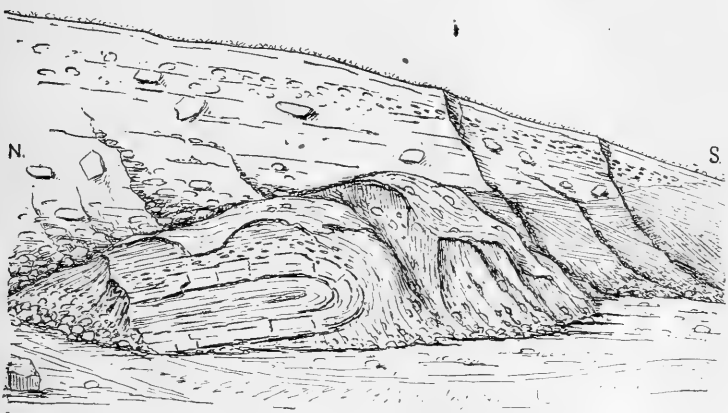

FIG. 4. OVERTHRUST FOLD UNDER TERMINAL MORAINE, CLIFTON, STATEN ISLAND.

the strata are either bent into overthrust folds or tilted, with the dip towards the north. North and south anticlines are common. A particularly fine example of the overthrust fold was exposed at Clifton, Staten Island, some years ago, in an excavation made on the edge of the moraine for building gravel (see Fig. 4).

On Long Island the hills on the north shore are much broken up by the numerous inlets and harbors which extend to a greater or less distance inland. On the east and west sides of these harbors there are several limited exposures, and these present sometimes the faces, sometimes the edges of the strata to view, and the dip is as often east or west as north or south.

In some instances this eccentricity may doubtless be accounted for by local land slips, but in other cases I am inclined to think that an east dip on the west side of a harbor or a west dip on the east side may be explained on the theory advocated by F. J. H. Merrill,* that these inlets are due to tongues of ice which were either in advance of or plowed deeper than the main mass. In such a case there would be a side thrust or squeeze along each of these inlets, which would produce the dips noted, in opposition to the generally prevailing north and south dips. On the north shore of Gardiner's Island may also be seen examples of east and west dips in the clay strata. (See Fig. 5.)

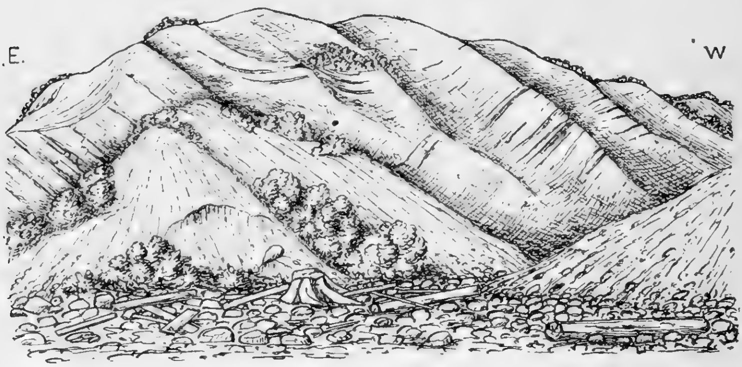

FIG. 5. DISTORTED CLAYS, NORTH SIDE OF GARDINER'S ISLAND.

Such an explanation would be not only in harmony with the theory of ice action in general, but also a special argument in favor of the formation of these harbors by the same agency.

I do not know whether the competency of ice to produce the effects noted will be questioned, but the distorting effects of even small superficial loads on clay strata, such as trees and bowlders, has been recognized, and the pronounced effects of comparatively weak thrusts upon yeilding strata are too well known to need extensive comment. It may perhaps be not out of place, however, to recall the prominent example of the landslide which occurred at Brantford, Ontario, April 15, 1884, by which the Erie clay was raised into truncated, anticlinal folds by the forward movement of the displaced mass at the limit of its furthest line of advancement. A brief account of the

* "On the Geology of Long Island," *l. c.*, 359.

phenomenon was written by J. W. Spencer,* and it is a most graphic illustration of the points in question.

In this connection I also wish to call attention to the recently published experiments by Bailey Willis† in the crumpling of plastic strata by a force advancing from one direction. If we compare his original models to sections of the former coastal plain and the force exerted by his piston to the force exerted by the advancing ice front, we have a parallel series of examples, and some of the pictures of the models after compression would serve as excellent charts of sections through the morainal region of the coastal plain to-day, particularly plates xcv. and xcvi. of the work mentioned. I am also pleased to say that after having come to the above conclusion I wrote to Mr. Willis and received from him a reply, from which I quote as follows: "Deformation in stratified layers under pressure occurs in different manner under three distinct conditions. * * * Now in your case the plastic quality of the clay affords a condition similar to that of excessive load upon more solid material. This was true also of models xcv. and xcvi, to which you refer. I presume there is no question but what the ice sheet was competent to produce the deformation."

Under the circumstances I am inclined to accept these conclusions as final until proven otherwise by evidence to the contrary, and to consider the phenomena of folding and dislocations as the visible effects of glaciation, from which we may calculate the extent of the cause. In other words, to utilize them as data from which to calculate the magnitude and extent of glacial action in quaternary time in this vicinity—a task, however, which I cheerfully leave to the glacialists.

COMPARISON OF THE THEORIES OF MOUNTAIN-MAKING FORCES AND ICE ACTION.

Considering the facts adduced, we have, in favor of the theory of ice action, the general structure of the morainal region of the coastal plain; the uniform coincidence of distorted coastal plain strata with the line of the moraine; the absence of any distortions where the moraine does not reach the plain; the much more pronounced distortions at localities where the moraine indicates an extensive advance of the ice over the plain

* "A landslide at Brantford, Ontario, illustrating the Effects of Thrusts upon yielding Strata," Am. Nat. xxi. (1887) 267-269, illustrated.

† "The Mechanics of Appalachian Structure," Thirteenth Ann. Rept. U. S. G. S. (1891-92) 217-281, pl. lxxv.-xcvi.

or its descent upon the plain over a hard rock escarpment; and the prevailing directions of dip and strike. Finally, I have not yet encountered a fact which could not be brought into harmony with the theory.

In regard to mountain-making forces as the probable agency in producing the phenomena, I fail to see that any of the arguments brought forward in support of this theory are not also applicable to the other, except perhaps the element of geologic age, in regard to which there is a difference of opinion on the part of observers. Prof. Shaler considers that the topography of the Martha's Vineyard hills was determined in pre-glacial times, and therefore could not have been due to glacial action. I can only say that I failed to see the evidence of this on Martha's Vineyard and that it is certainly not the case at any other locality.

Again, if we are to regard the line of the moraine as a line along which mountain-making forces have been in action and to consider that the distortions of strata are the principal evidences of such action, we must assume that, on Staten Island, the force which had acted thus far consistently from Nantucket and Martha's Vineyard ceased suddenly to be manifested where the ice front curved away from the coastal plain, and did not again make itself apparent except at and beyond the point where the ice once more entered upon the plain. On this theory we should also have to dismiss, as unworthy of serious thought, the weight of arugment implied by the coincidence of the distorted strata and the moraine, or to consider it merely as somewhat curious that the moraine should find a line of disturbance all ready and waiting to mark its exact limit of southern advancement over the coastal plain. We should have to regard all this as a coincidence only, and we should have to face the improbable circumstance that a line of mountain-making forces had been developed practically at right angles to the direction in which previous observations have taught us to expect that it would be developed. Further than this, as directly opposed to the facts, is the rapidity with which the distortions must have been accomplished in order to be be consistent with such a theory. Thus we find beds of unmistakable "Yellow Gravel," the equivalent of the Lafayette formation, included as part of the distorted strata, showing that the disturbance took place subsequent to the period when these gravels were laid down, and all authorities are practically agreed now that this formation is at least as recent as Pliocene. Considering this fact alone it would leave but a very brief period of time in which to develop the "pre-glacial topography," by which term

Professor Shaler designates the hills of contorted clays, sands and gravels upon which the moraine rests. It would imply a very great stress, suddenly and violently discharged, almost in the nature of an eruption in fact, and not a gradual mountain-making process, and so far as my experience goes, the facts do not warrant us in assuming that any such conditions have prevailed.

Finally any such development of force would result in the disturbance of strata far below the surface as well as above, and this we do not find to be the case. At Cold Spring, the superficial strata are beautifully crumpled, but where the lower strata are exposed these are seen to be undisturbed. This is the only locality in which I have been able to note this interesting and significant fact, but there is no doubt that if excavations below the limit of ice action were made at other localities, similar conditions would be found to exist.

In consideration of these circumstances it would seem as if any other reasonable theory than that of mountain-making forces, to account for the phenomena observed, ought to be welcomed, and the theory of ice action, in connection with the continental glacier of the Ice Age, has seemed to the writer to be an adequate and rational one. The facts are in harmony with it; it enables us to consider the entire area of disturbance as a comprehensive whole, with one series of cause and effect throughout, and not as a number of isolated districts in which similar phenomena are to be accounted for on different hypotheses. It is also a theory which nothing in our previous observation or experience would cause us to doubt, and is one which has been extensively applied to what are apparently identical phenomena in Europe, especially on the islands of Moën* and Rügen,† in Denmark.

I have elsewhere‡ called attention to the fact that observers who visited Martha's Vineyard in 1786 promptly ascribed a volcanic origin to Gay Head,§ and it is of interest to note, as

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*Jas. Geekie, "Prehistoric Europe.

Vide p. 200: "Here and there irregular-shaped masses of bowlder-clay are actually surrounded on all sides by chalk, and so striking indeed is the behaviour of the bowlder-clay that Forchhammer may well be pardoned for having speculated upon its eruptive origin. Puggard was of opinion that all this confusion was due to movements of the earth's crust, to convulsions and "faults" caused by the action of the subterranean forces, and in this view he was followed by Lyell. But Johnstrup has since reinvestigated the evidence and come to quite a different conclusion. He shows * * * that the disturbances can only be attributed to the enormous pressure and disrupting force of the Scandinavian *mer de glace*."

†Rudolph Credner, "Rügen. Eine Inselstudie," Forsch. z. Deutsch. Land. u. Volkskunde, vii. No. 5 (1893).

‡"Observations on the Geology and Botany of Martha's Vineyard," *l. c.*, 9-12.

§Samuel West and William Baylies, Mem. Am. Acad. Arts and Sci. ii., part i., 147-150 (1793), and 150-155 (1797.)

previously quoted, that the earlier observers in Europe were unable to consider any other than orogenic forces in order to account for similar distortions there. They were either in ignorance of or else had not been educated up to a full appreciation of the Ice Age and the magnitude of its phenomena. The practical unanimity of opinion both here and abroad in assuming ice action as the agency which was instrumental in producing these effects seems now, however, to be assured.

In the discussion that followed, Mr. H. Ries referred to the heavy crumpling of the upper portion of the clays on Fisher's Island, which is due to the ice of the glacial period. The disturbed portions are in places mixed with the boulder till, which caps the section with a thickness of 15–20 ft. Mention was also made of local crumplings in single layers from overlying weights and landslides. Dr. Julien spoke of a horizontal bed of pre-glacial oyster shells beneath Nantucket.

Professor Whitfield cited local crumplings in the clays at Albany, N. Y., due to the weight of a tree growing above them, or to a bowlder resting on them, these being marked when the clay rested on yielding sands.

The last paper of the evening was by Mr. Gilbert van Ingen, A Sketch of the Cambrian Strata near St. John, N. B.

The paper was illustrated by maps, photographs and numerous specimens of fossils. After a brief discussion the Academy adjourned.

J. F. KEMP, *Recording Secretary.*

STATED MEETING.

October 22d, 1894.

Professor H. F. OSBORN in the Chair; an attendance of thirty.

The following papers were read by title for publication in the Annals.

The *South American Cat-fishes* belonging to Cornell University, by Edward M. Kindle.

The *South American Characinidæ*, collected by Albert B. Ulrey.

The Biological Section organized. The first paper of the evening was the following:

AN ENUMERATION OF THE PLANTS COLLECTED BY DR. TIMOTHY E. WILCOX, U. S. A., AND OTHERS IN SOUTHEASTERN ARIZONA DURING THE YEARS 1892–1894.

By N. L. Britton and T. H. Kearney, Jr.

The plants enumerated in this list were collected in the neighborhood of Fort Huachuca, by Dr. T. E. Wilcox, and about Fort Apache, by Mrs. Capt. R. W. Hoyt. A few were collected near San Carlos and in Tanner's Cañon, by Dr. R. G. Ebert, U. S. A. Where no locality and collector is mentioned, it is understood that the plant was obtained by Dr. Wilcox, near Fort Huachuca. The greater part of the collection of 1892–93 was made by Dr. Wilcox, and was sent by him to the Herbarium of Columbia College. Further collections were made by Dr. Wilcox in 1894 and were deposited in the United States National Herbarium. These have been submitted to us for determination by Mr. F. V. Coville and have been included in the present enumeration.

The Gramineæ of the entire collection have been determined by Prof. F. Lamson-Scribner, whose valuable notes and descriptions add much to the interest of the list. Part of the collections of 1892 were named by Mr. Henry Kraemer, of Columbia College. To Dr. B. L. Robinson, we are indebted for the privilege of comparing some of the more difficult species with the types preserved in the Herbarium of Harvard University.

Despite the fact that the flora of this part of Arizona Territory has been much-explored, the present collection is of considerable interest. It contains many rare and little-known plants, a number of species new to the United States and a few that are new to science. It is to be hoped that the collectors will have an opportunity to continue their valuable contributions to our knowledge of the plant-life of this region.

The present contribution is made in the hope that a more extended study of the flora of the Territory may be undertaken in the future. The vegetation of New Mexico and Arizona is of peculiar interest, both in itself and from the standpoint of geographical botany. A work which shall bring together systematically what is known of it is a desideratum in the literature of botany.

CHARACEÆ.

Chara contraria A. Br.

FILICES.

Adiantum Capillus-Veneris L. Sp. Pl. 1096 (1753).
Cheilanthes Fendleri Hook. Sp. Fil. **2** : 103, *t. 107* (1846–64).
Cheilanthes lanuginosa Nutt. ; Hook. Sp. Fil. **2** : 99 (1846–64).
Cystopteris fragilis (L.) Bernh. Schrader's Neues Journ. Bot. **1** : Part 2, 27 (1806).
Notholæna ferruginea (Desv.) Hook. Sp. Fil. **5** : 108 (1864).
Notholæna sinuata (Sw.) Kaulf. Enum. Fil. 135 (1824).
Pellæa atropurpurea (L.) Link, Fil. Hort. Berol. 59 (1841). Mrs. Hoyt, Ft. Apache.
Pellæa Wrightiana Hook. Sp. Fil. **2** : 142 (1846–64). Mrs. Hoyt, Ft. Apache ; Dr. Wilcox, Ft. Huachuca.
Pteris aquilina lanuginosa (Bory) Hook. Fl. Bor. Am. **2** : 263 (1840).

EQUISETACEÆ.

Equisetum lævigatum A. Br. ; Engelm. Am. Journ. Sci. **46** : 87 (1844).

CONIFERÆ.

Abies concolor (Engelm.) Lindl. Journ. Hort. Soc. **5** : 210 (1850). Dr. Wilcox, Mt. Graham.
Cupressus Arizonica Greene, Bull. Torr. Club, **9** : 64 (1882).
Juniperus occidentalis Hook. Fl. Bor. Am. **2** : 166 (1840).
Juniperus pachyphlæa Torr. Pac. R. R. Rep. **4** : 142 (1856).
Juniperus Virginiana L. Sp. Pl. 1039 (1753). Mrs. Hoyt, Ft. Apache.
Pinus Arizonica Engelm. ; Rothr. Wheeler Rep. **6** : 260 (1878). "On the peak known as Nigger Head, at 7,000 feet and higher."
Pinus cembroides Zucc. Pl. Nov. Fasc. **1** : 392 (1837–40).
Pinus Chihuahuana Engelm. ; Wisliz. Mem. Tour N. Mex. 103 (1848). Dr. Wilcox, Ft. Huachuca ; Dr. Ebert, Tanner's Cañon.
Pinus edulis Engelm. ; Wisliz. Mem. Tour N. Mex. 88 (1848). Mrs. Hoyt, Ft. Apache ; Dr. Ebert, San Carlos.
Pinus latifolia Sarg. Gard. & For. **2** : 496 (1889).
Pinus ponderosa scopulorum S. Wats. Bot. Cal. **2** : 126 (1880). Mrs. Hoyt, Ft. Apache ; Dr. Wilcox, Ft. Huachuca.
Pinus reflexa Engelm. ; Coult. Bot. Gaz. **7** : 4 (1882).
Pseudotsuga taxifolia (Lamb.) Britton, Trans. N. Y. Acad. Sci. **8** : 74 (1889).
This may be the var. *suberosa* Lemmon (Erythea, **1** : 48) described as being a small tree with whitish, thick, corky bark, so soft that it can be readily cut with a pocket-knife. Dr. Wilcox, Ft. Huachuca ; Mrs. Hoyt, San Carlos ; Dr. Ebert, Tanner's Cañon.

GNETACEÆ.

Ephedra trifurca Torr. Emory's Rep. 153 (1848).

GRAMINEÆ *

Agropyron sp. = 1439 Pringle Mexican Coll. (1887) distributed as *A. divergens* Nees. Also = 2929 Lemmon in Nat. Herb from Huachuca Mts. (1882). *Triticum caninum* Thurb. in S. Wats. Bot. Cal. **2** : 324. *Agropyrum divergens* Vasey, Ill. N. Am. Grasses **2** : 96. Specimens of *A. scabrum* from Australia agree very well with this plant.
Agrostis verticillata Vill. Prosp. 16 (1779).
Andropogon cirratus Hack. Fl. **68** : 119 (1885) var.
Andropogon contortus L. Sp. Pl. 1045 (1753).
Andropogon hirtiflorus Kunth, Rev. Gram. **2** : 569, *t. 198* (1835).
Andropogon melanocarpus (Muhl.) Ell. Sk. **1** : 146 (1817–18).
Andropogon saccharoides barbinodis (Lag.) Hack. ; D.C. Mon. Phan. **6** : 494 (1889).
Andropogon saccharoides laguroides (DC.) Hack. ; Mart. Fl. Bras. **2** : Pt. 3, 293 (1878–83).
Andropogon semiberbis Kunth, Enum. **1**: 489 (1833) ; with *Muhlenbergia distichophylla*.
Andropogon tener Kunth. Rev. Gram. **2** : 565, *t. 197* (1835).
Aristida Americana L. Amœn. Acad. **5** : 393 (1759). (*A. dispersa* Trin. & Rupr. Mém. Acad. Pétersb. (VI.) **7** : 129 (1849).
Aristida bromoides H.B.K. Nov. Gen. et Sp. **1** : 122 (1815).
Aristida fasciculata Torr. Ann. Lyc. N. Y. **1** : 154 (1824).
ARISTIDA FASCICULATA FENDLERIANA (Steud.) Scribn. (*A. Fendleriana* Steud.) (*A. purpurea Fendleriana* Vasey, Contrib. U. S. Nat. Herb. **3** : 46 (1892).
Aristida Havardii Vasey, Bull. Torr. Club, **13** : 27 (1886).
Aristida Humboldtiana Trin. & Rupr. Mém. Acad. Pétersb. (VI.) **7** : 118 (1849).
ARISTIDA LEMMONI Scribn. n. sp. Slender, densely cæspitose, 3–5 dm. high ; culms simple, smooth ; sheaths smooth, barbate on the sides at the throat with white flocculent hairs ; ligule very short, minutely ciliate ; leaf-blades involute-filiform or flat near the base and scarcely 1 mm. wide, those of the culm 10–20 cm. long. Panicles 20–25 cm. long, the branches slender, almost capillary, in pairs, ascending or finally spreading, naked below ; the lower branches 7–12 cm. long. Flowering glumes 10–12 mm. long, slender, twisted above, scarcely longer than the long-attenuate-pointed, smooth and nearly equal empty glumes. Callus nearly 1 mm. long, short-barbate. Awns 10–12 mm. long, nearly equal, becoming divergent. = 388 Lemmon, Arizona, 1882, in Nat. Herb.
Aristida longifolia Trin. Mém. Acad. Pétersb. (VI.) **1** : 84 (1831).
Aristida Reverchonii Vasey, Bull. Torr. Club, **13** : 52 (1886).
Aristida scabra Kunth, Rev. Gram. **1** : 62 (1830). Perhaps *A. tenuis* Kunth, Rev. Gram. **1** : 62 (1835).
Aristida Schiedeana Trin. & Rupr. Mém. Acad. Pétersb. (VI) **7** : 120 (1849).
Bouteloua aristidoides (H.B.K.) Thurb. ; S. Wats. Bot. Calif. **2**: 291 (1880).

* Determined by Prof. F. Lamson-Scribner.

Bouteloua bromoides (H.B.K.) Lag. Gen. et Sp. Nov. 5 (1816).

The spikelets in the specimens received in 1894 are exactly those of *Dinebra repens* H.B.K. *Dinebra repens* and *Dinebra bromoides* were united under *B. bromoides* by S. Watson in Proc. Am. Acad. **18**: 177.

Bouteloua curtipendula (Michx.) Torr. Emory Rep. 154 (1848).

Bouteloua eriopoda Torr. Pacif. R. R. Rep. **4** : 155 (1856).

Bouteloua Havardii Vasey ; S. Wats. Proc. Am. Acad. **18** : 179 (1883).

From description of *Dinebra chondrosioides* H.B.K., this *Bouteloua Havardii* appears to be essentially that species.

Bouteloua hirsuta Lag. Varied. Cienc. **2** : Pt. 4, 141 (1805).

Bouteloua oligostachya (Nutt.) Torr. ; A. Gray Man. Ed. 2, 553 (1856).

Bouteloua Rothrockii Vasey, Contrib. U. S. Nat. Herb. **1** : 268 (1893).

Bromus maximus Desf. Fl. Atl. **1** : 95 (1798–1800).

Bromus Kalmii A. Gray, Man. 600 (1848). Dr. Ebert, Tanner's Cañon.

Bromus ciliatus L. Sp. Pl. 76 (1753).

Bromus sterilis L. Sp. Pl. 77 (1753).

Bromus unioloides (Willd.) H.B.K. Nov. Gen. et Sp. **1** : 151 (1815).

Chloris elegans H.B.K. Nov. Gen. et Sp. **1** : 166 (1815).

Cottea pappophoroides Kunth, Rev. Gram. **1** : 84, 281, *t. 52* (1830).

Eatonia obtusata (Michx.) A. Gray, Man. Ed. 2, 558 (1856).

Elionurus barbiculmis Hack. ; D.C. Mon. Phan. **6** : 339 (1889). Very near *E. candidus.*

Epicampes rigens Benth. Journ. Linn. Soc. **19** : 88 (1882).

Eragrostis Caroliniana (Spreng.) Scribn. Mem. Torr. Club **5** : 49 (1894).

Eragrostis diffusa Buckl. Proc. Acad. Phila. (1862) 97 (1863). Perhaps distinct from *E pilosa.*

Eragrostis limbata Fourn. ; Hemsl. Bot. Centr. Am. **3** : 573 (1882–86).

May include *E. Neo-Mexicana* Vasey. Some forms have been referred to *E. Purshii.* E. Palmer collected the same form at Climo, Mexico. Spikelets larger than in *E. Purshii.* The spikelets are about the size of those of *E. minor*, but the glumes are all more acute.

Eragrostis lugens Nees ; Mart. Fl. Bras. **2** : Pt. 1, 505 (1829).

Eragrostis major Host. Gram. Austr. **4**, 14, *t. 24* (1809).

Eragrostis tenuis Texensis Vasey, Contr. U. S. Nat. Herb. **1** : 59 (June, 1890).

Leaves in type [of *E. tenuis*] much narrower and panicle a foot to 18 inches long. Spikelets 6–8-flowered. Glumes all acute, the floral strongly 3-nerved and submucronate-pointed.

Eriochloa punctata W. Hamilt. Prodr. Fl. Ind. Occ. 5 (1825).

Festuca octoflora Walt. Fl. Car. 81 (1788).

Hackelochloa granularis (L.) Kuntze, Rev. Gen. Pl. 776 (1891).

Hilaria cenchroides H.B.K. Nov. Gen. et Sp. **1** : 117 (1815).

Hilaria mutica (Buckl.) Benth. Journ. Linn. Soc. **19** : 62 (1882).

Hordeum murinum L. Sp. Pl. 85 (1753).

Kœleria cristata (L.) Pers. Syn. **1** : 97 (1805).

Leptochloa dubia (H.B.K.) Nees ; Mart. Fl. Bras. **2** : Pt. 1, 433 (1829). Apparently a reduced form.

Lycurus phleoides H.B.K. Nov. Gen. et Sp. **1** : 142 (1815).

Muhlenbergia affinis Trin. Agrost. **2** : 55 (1841).

Muhlenbergia Arizonica Scribn. Bull. Torr. Club **15** : 8 (1888).

Muhlenbergia distichophylla (Presl.) Kunth, Enum. **1** : 202 (1833).

Muhlenbergia gracilis Trin. Unifl. 193 (1824).

Muhlenbergia Lemmoni Scribn. ; Coult. Contr. U. S. Nat. Herb. **1** : 56 (1890). (*M. Huachucana* Vasey, Contr. U. S. Nat. Herb. **3** : 69 (1892).

MUHLENBERGIA PRINGLEI Scribn. (*M. sylvatica Pringlei* Scribn. Bull. Torr. Club, **9** : 89 (1882). (*M. Neo-Mexicana* Vasey ; Coult. Bot. Gaz. **11** : 337 (1886).

Muhlenbergia Texana Thurb. ; Coult. Bot. Rocky Mt. Reg. 410 (1885).

Muhlenbergia virescens Trin. Unifl. 193 (1824).

Nazia racemosa (L.) Kuntze, Rev. Gen. Pl. 780 (1891).

Oryzopsis fimbriata (H.B.K.) Hemsl. Bot. Centr. Am. **3** : 538 (1882–86).

Panicum avenaceum H.B.K. Nov. Gen. et Sp. **1** : 99 (1815).

Panicum capillare L. Sp. Pl. 58 (1753).

Panicum capillare L. var.

Panicum Carthaginense Sw. Fl. Ind. Occ. **1** : 148 (1797).

Spikelets 1.5 lines long. Second and third glumes abruptly acute-pointed. Glume of the hermaphrodite flower apiculate. Third glume with a staminate flower in its axil. (Det. ex descr. in Grisebach Fl. Brit. W. Ind. 546 (1864).)

Panicum Carthaginense Sw. var. Spikelets glabrous.

Panicum Crus-Galli L. Sp. Pl. 56 (1753).

Panicum Hallii Vasey, Bull. Torr. Club, **11** : 61 (1884).

Closely related to *P. capillare* and has been regarded as a variety of that species. Spikelets 1.5 lines long, acuminate-pointed ; pedicels rather short and for the most part appressed to the more or less spreading panicle-branches.

Panicum lachnanthum Torr. Pac. R. R. Rep. **7** : Pt. 3, 21 (1856).

Panicum obtusum H.B.K. Nov. Gen. et Sp. **1** : 98 (1815).

Panicum sanguinale L. Sp. Pl. 57 (1753).

Pappophorum Wrightii S. Wats. Proc. Am. Acad. **18** : 178 (1883).

Poa Fendleriana Vasey, Grasses Pacif. Slope, **2**: 74 (1893).

Polypogon Monspeliensis (L.) Desf. Fl. Atl. **1** : 67 (1798–1800).

Setaria caudata* (Lam.) R. & S. Syst. **2** : 495 (1817).

Setaria pauciseta Vasey, Contr. U. S. Nat. Herb. **3** : No. 1, 39 (1892).= 2069 C. Wright, Texas ; and 676 Rothr. (1874).

Setaria setosa Beauv. Agrost. 51, 178 (1812).

Sieglingia avenacea grandiflora (Vasey) Dewey ; Coult. Contr. U. S. Nat. Herb. **2**: 538 (1894). *Triodia grandiflora* Vasey, Ill. N. Am. Grasses **1** : Pt. 2, *t. 35* (1891).

Sieglingia mutica (Torr.) Kuntze, Rev. Gen. Pl. 789 (1891).

Sieglingia pulchella (H.B.K.) Kuntze, Rev. Gen. Pl. 789 (1891).

Sporobolus confusus (Fourn.) Vasey, Bull. Torr. Club **15** : 293 (1888).

(*Sporobolus ramulosus* Am. auct. not Kunth, teste Vasey.) The grass published by Vasey as *S. racemosus* may be the true *Sporobolus ramulosus* Kunth.

Sporobolus tricholepis (Torr.) Vasey, Contr. U. S. Nat. Herb. **3** : 62 (1892).

Sporobolus Wrightii Scribn. Bull. Torr. Club **9** : 103 (1882).

Trachypogon polymorphus Montufari (H.B.K.) Hack. ; DC. Mon. Phan. **6** : 325 (1889).

CYPERACEÆ.

Carex† *marcida* Boott ; Hook. Fl. Bor. Am. **2** : 212 (1840).

Carex Thurberi Dewey ; Torr. Bot. Mex. Bound. 232 (1859). *C. hystricina angustior* Bailey ; Rose, Contr. U. S. Nat. Herb. **1** : No. 4, 126 (1891).

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* As the species of *Setaria* Beauv. are not congeneric with *Chamæraphis* R. Br., the name *Setaria* has been retainrd for them here, though it is a homonym of *Setaria* Achar.

† Determined by Prof. L. H. Bailey.

Carex ultra, Bailey Proc. Am. Acad **22** : 83 (1887).
Cyperus esculentus L. Sp. Pl. 45 (1753).
Cyperus Fendlerianus Bœckl. Linnæa, **35**: 520 (1867–68).
Cyperus ferax Rich. Act. Soc. Hist. Nat. Par. **1** : 106 (1792).
Cyperus Meyenianus Kunth, Enum. **2** : 88 (1837.) New to the U. S.
Cyperus Schweinitziidebilis Britton, Bull. Torr. Club, **13** : 208 (1886).
Cyperus seslerioides H.B.K. Nov. Gen. **1**: 209 (1815).

COMMELINACEÆ.

Commelina dianthifolia Delile ; Red. Lil. **7** : *t. 390* (1802–16).
Tradescantia tuberosa Greene ; Coult. Bot. Gaz. **6** : 185 (1881). Closely resembles *T. linearis* Benth. and may be identical with it.

JUNCACEÆ.*

Juncus Balticus Willd. Ges. Naturf. Fr. Berl. Mag. **3** : 298 (1809).
Juncus bufonius L. Sp. Pl 328 (1753).
Juncus tenuis Willd. Sp. Pl. **2** : 214 (1799).
Juncus xiphioides montanus Engelm. Trans. St. Louis Acad. Sci. **2** : 481 (1868).

LILIACEÆ.

Allium cernuum Roth ; Roem. Archiv. **1** : Pt. 3, 40 (1798).
Allium scaposum Benth. Pl Hartweg. 26 (1840).
Androstephium cœruleum (Scheele) Greene, Pitt. **2**: 57 (1890).
Anthericum Torreyi Baker, Journ. Linn. Soc. **15** : 317 (1877) ? Leaves only 10–20 cm. long. Pedicel articulated just below the middle.
Brodiæa capitata Benth. Pl. Hartweg. 339 (1857).
Calochortus Gunnisoni S. Wats. Bot. King's Rep. 348 (1871).
Dasylirion Wheeleri S. Wats.; Rothr. Wheeler Rep. **6** : 272 (1878).
Milla biflora Cav. Icon. **2** : 76, *t. 196* (1793).
Nolina Lindheimeriana (Scheele) S. Wats. Proc. Am. Acad. **14** : 247 (1879).
Polygonatum biflorum (Walt.) Ell. Sk. **1** : 393 (1817–18).
Vagnera racemosa (L.) Morong, Mem. Torr. Club, **5** : 114 (1894). Mrs. Hoyt, Ft. Apache ; Dr. Wilcox, Ft. Huachuca.
Yucca angustifolia Pursh, Fl. Am. Sept. 227 (1814).
Zygadenus elegans Pursh, Fl. Am. Sept. 241 (1814).

AMARYLLIDACEÆ.

Agave Palmeri Engelm. Trans. St. Louis Acad. Sci. **3** : 319 (1878)
Agave Parryi Engelm. Trans. St. Louis Acad. Sci. **3** : 311 (1878). ?
Zephyranthes longifolia Hemsl. Diag. Pl. Nov. 55 (1879).

IRIDACEÆ.

Sisyrinchium Arizonicum Rothr.; Coult. Bot. Gaz. **2** : 125 (1877).

ORCHIDACEÆ.

Epipactis gigantea Dougl. ; Hook. Fl. Bor. Am. **2** ; 202, *t. 202* (1840).
Habenaria sp. "Strongly resembles *H. leucostachys* (Lindl) S. Wats., but the petals and sepals and lip much smaller."—Morong.

Determined by Mr. F. V. Coville.

JUGLANDACEÆ.

Juglans Californica S. Wats. Proc. Am. Acad. **10**: 349 (1875).

SALICACEÆ.

Salix nigra Wrightii Anders. Mon. Sal. 22 (1867).

BETULACEÆ.

Alnus oblongifolia Torr. Bot. Mex. Bound. 204 (1859). "Tree 40 ft. high and 18 in. in diameter."—Dr. Ebert, Ft. Grant.

FAGACEÆ.

Quercus chrysolepis Liebm. Dank. Vidensk. Selsk. Forhandl. (1854) 173 (1854).
Quercus Emoryi Torr. Emory Rep. 152, *t. 9* (1848).
Quercus Gambellii Nutt. Journ. Acad. Phila. (II.) **1**: 179 (1847–50).
Quercus hypoleuca Engelm. Trans. St. Louis Acad. Sci. **3** : 384 (1878).
Quercus oblongifolia Torr. Sitgr. Rep. 173, *t. 19* (1853).
Quercus undulata Torr. Ann. Lyc. N. Y. **2** : 248, *t. 4* (1828). A very pubescent form, with leaves almost as much reticulated beneath as *Q. reticulata*.
Quercus undulata grisea (Liebm.) Engelm. Trans. St. Louis Acad. Sci. **3** : 393 (1878).

ULMACEÆ.

Celtis Mississippiensis Bosc. Encyc. Agr. **7** : 577 (1822).
Celtis reticulata Torr. Ann. Lyc. N. Y. **2** : 247 (1828). Dr. Ebert, Ft. Grant; Dr. Wilcox, Ft. Huachuca.

MORACEÆ.

Humulus Lupulus L. Sp. Pl. 1028 (1753).

URTICACEÆ.

Urtica holosericea Nutt. Journ. Acad. Phila. (II.) **1** : 183 (1847–50).

LORANTHACEÆ.

Phoradendron flavescens pubescens Engelm.; A. Gray Bost. Journ. Nat. Hist. **6** : 212 (1857).
Phoradendron juniperinum Engelm.; A. Gray Mem. Am. Acad. (II.) **4** : 58 (1849).
Razoumofskya cryptopoda (Engelm.) Coville, Contr. U. S. Nat. Herb. **4** : 192 (1893). On *Pinus ponderosa scopulorum*.

SANTALACEÆ.

Comandra pallida A.D.C.; DC. Prodr. **14** : 636 (1857).
Comandra umbellata (L.) Nutt. Gen. **1** : 157 (1818).

POLYGONACEÆ.

Eriogonum Abertianum Torr. Emory Rep. 151 (1848).
Eriogonum hieracifolium Benth.; DC. Prodr. **14** : 6 (1857)? Mrs. Hoyt, Ft. Apache.
Eriogonum Jamesii Benth. DC. Prodr. **14** : 7 (1857).

Eriogonum polycladon Benth ; DC. Prodr. **14** : 16 (1857).
Eriogonum trichopes Torr. Emory Rep. 151 (1848).
Mrs. Hoyt, San Carlos.—What is apparently a stouter and fewer-flowered form of *E. trichopes*, with larger and less spreading peduncles, was collected by Dr. Ebert at San Carlos.
Eriogonum Wrightii Torr. in Benth. ; DC. Prodr. **14** : 15 (1887).
Polygonum Convolvulus L. Sp. Pl. 364 (1753).
Polygonum Persicaria L. Sp. Pl. 361 (1753).

CHENOPODIACEÆ.

Chenopodium cornutum (Torr.) B. & H. ; S. Wats. Bot. Calif. **2**: 482 (1880).

AMARANTHACEÆ.

Cladothrix lanuginosa Nutt. Moq. in DC. Prodr. **13** : Pt. 2, 360 (1849).
Frœlichia Floridana (Nutt.) Moq. ; DC. Prodr. **13** : Pt. 2, 420 (1849).
Gomphrena cæspitosa Torr. Bot. Mex. Bound. 181 (1859).
Guilleminea illecebroides H.B.K. Nov. Gen. et Sp. **6** : 42, *t. 518* (1823).

NYCTAGINACEÆ.

Allionia linearifolia (S. Wats.) Kuntze, Rev. Gen. Pl. 533 (1891).
Allionia nyctaginea Michx. Fl. Bor. Am. **1** : 100 (1803).
Bœrhaavia erecta L. Sp. Pl. 3 (1753).
Bœrhaavia purpurascens A. Gray, Am. Journ. Sci. (II.) **15** : 321 (1853).
Bœrhaavia spicata Choisy ; DC. Prodr. **13** : Pt. 2, 456 (1849).
Mirabilis coccinea (Torr.) B. & H. Gen. Pl. **3** : Pt. 1, 3 (1880).
Mirabilis multiflora (Torr.) A. Gray ; Torr. Bot. Mex. Bound. 169 (1859). Mrs. Hoyt, Ft. Apache.
MIRABILIS WRIGHTIANA A. Gray ined. No description of this species appears to have been published. It differs from *M. longiflora* L. to which Wright's plant (No. 1702) was first referred, in its much more slender and less glandular calyx-tube, thinner and less glandular leaves ; and from *M. Jalapa* L., with which it nearly accords in foliage, in its much longer calyx-tube, this being from 3 to 5 inches long.
Wedelia incarnata (L.) Kuntze, Rev. Gen. Pl. 534 (1891). Mrs. Hoyt, Ft. Apache ; Dr. Wilcox, Ft. Huachuca.

AIZOACEÆ.

Mollugo verticillata L. Sp. Pl. 89 (1753).
Trianthema monogyna L. Mant. 69 (1767).

PORTULACACEÆ.

Portulaca lanceolata Engelm. ; A. Gray Bost. Journ. Nat. Hist. **6** : 154 (1857).
Portulaca suffrutescens Engelm. ; Coult. Bot. Gaz. **6** : 236 (1881).
Talinum lineare H.B.K. Nov. Gen. et Sp. **6** : 77 (1823).
Talinum patens Willd. Sp. Pl. **2** : 863 (1800).

CARYOPHYLLACEÆ.

Arenaria saxosa A. Gray, Pl. Wright. **2** : 18 (1853).
Cerastium brachypodum (Engelm.) Rob. Mem. Torr. Club, **5** : 150 (1894).
Cerastium Texanum Britton, Bull. Torr. Club, **15** : 97 (1888).

Drymaria sperguloides A. Gray, Mem. Am. Acad. (II.) **4** : 11 (1849).
Silene antirrhina L. Sp. Pl. 419 (1753).
Silene laciniata Greggii (A. Gray) S. Wats. Bibl. Ind. **1**: 108 (1878).

RANUNCULACEÆ.

Anemone cylindrica A. Gray, Ann. Lyc. N. Y. **3** : 221 (1836). Mrs. Hoyt, Ft. Apache.
Anemone sphenophylla Poepp. Fragm. Syn. 27 (1833).
Aquilegia chrysanha A. Gray, Proc. Am. Acad **8** : 621 (1873).
Clematis Bigelovii Torr. Pac. R. R. Rep. **4**: Pt. 4, 61 (1857). Mrs. Hoyt, Ft. Apache ; Dr. Wilcox, Ft. Huachuca.
Clematis dioica L. Sp. Pl. Ed. 2, 765 (1762). ? Specimens of the staminate plant, referred to this species with hesitation. It is apparently otherwise unknown from the United States.
Clematis Drummondii Torr. & Gray, Fl. N. Am. **1** : 9 (1839).
Clematis ligusticifolia Nutt. ; Torr. & Gray, Fl. N. Am. **1**: 9 (1838).
Cyrtorhyncha Cymbalaria (Pursh) Britton Mem. Torr. Club, **5**: 161 (1894.)
Delphinium Carolinianum Walt Fl. Car. 155 (1788).
Delphinium scaposum Greene ; Coult. Bot. Gaz. **6** : 156 (1881). Mrs. Hoyt, Ft. Apache.
Delphinium scopulorum A. Gray, Pl. Wright. **2** : 9 (1853).
Myosurus cupulatus S. Wats. Proc. Am. Acad. **17** : 362 (1882).
Ranunculus Arizonicus Lemmon ; A. Gray, Proc. Am. Acad. **21** : 370 (1886).
Ranunculus macranthus Scheele, Linnæa, **21** : 585 (1848).
Thalictrum Fendleri Engelm. A. Gray, Mem. Am. Acad. (II.) **4** : 5 (1849).

BERBERIDACEÆ.

Berberis Aquifolium Pursh, Fl. Am. Sept. 219 (1814). *B. repens* Lindl. Bot. Reg. *t. 1176* (1828). It was to the low-stemmed plant of the Plains and Rockies, not to the tall shrub of the Pacific Slope, that Pursh applied this name. The name to be taken for the latter is BERBERIS NUTKANA (DC.) Kearney. = *Mahonia Aquifolium Nutkana* DC. Prodr. **1** : 108 (1824).
Berberis Fremontii Torr. Bot. Mex. Bound. 30 (1859). Mrs. Hoyt, Ft. Apache ; Dr. Ebert, San Carlos.
BERBERIS WILCOXII Kearney n. sp. Whole plant smooth and glabrous; stem woody, prostrate (?), branched ; bark reddish-brown ; leaves pinnate, 12–16 cm. long from the base of the petiole to the apex of the terminal leaflet ; leaflets 5–7, the lateral ones sessile, the terminal on a stalk 10–25 mm. long, articulated by the base of the midrib to the rhachis, which is itself articulated at the points where the leaflets are attached, 2.5–5.5 cm. long, 2–3 cm. wide, oblong-ovate to ovate-lanceolate, acuminate and spine-tipped or truncate at apex, rounded or wedge-shaped and (the lateral) unequal at base, irregularly and coarsely dentate with spreading, rigid, spiny teeth (7–11 in number), upper surface green and shining, with a deep crimson spot at base of midrib, lower surface pale but hardly glaucous ; veins pinnate, much reticulated, prominent on both surfaces; flowers in short, dense clustered racemes, arising from scaly axillary or terminal buds, each articulated to a slender pedicel which is dilated at summit, articulated to the rachis and subtended at base by a persistent, ovate, obtuse or acutish membranaceous bract ; calyx and corolla bright yellow ; fruit about 1 cm. long, dark blue, glaucous.

Nearest to *B. pinnata* Lag., from which, however, it is abundantly distinct. The lowest pair of leaflets is much farther from the base of the petiole than in *B. pinnata;* the teeth are fewer, larger and more spreading; the under leaf-surface is quite glaucous, while in *pinnata* it is at most merely paler than the upper; and the veins are much more prominent. Collected by Mr. Lemmon, Tanner's Cañon, Huachuca Mts.; Dr. Wilcox, Ft. Huachuca.

PAPAVERACEÆ.

Argemone platyceras Link & Otto, Ic. **2**: 43 (1831). Mrs. Hoyt, Ft. Apache; Dr. Wilcox, Ft. Huachuca.

Capnoides montanum (Engelm.) Britton, Mem. Torr. Club, **5**: 166 (1894).

CRUCIFERÆ.

Draba aurea stylosa A. Gray, Am. Journ. Sci. (II.) **33**: 243 (1862)?

Specimen with but one even approximately mature silique, which is strongly once twisted; but the fine stellular pubescence distinguishes it from *D. streptocarpa.* Apparently the same as Fendler's No. 43.

Draba cuneifolia Nutt.; Torr. & Gray, Fl. N. Am. **1**: 108 (1838). Mrs. Hoyt, Ft. Apache.

Erysimum asperum DC. Syst. Veg. **2**: 505 (1821).

Lepidium montanum Nutt.; Torr. & Gray, Fl. N. Am. **1**: 116 (1838–40).

Lesquerella Fendleri (A. Gray) S. Wats. Proc. Am. Acad. **23**: 254 (1888). Mrs. Hoyt, Ft. Apache.

Roripa Nasturtium (L.) Rusby, Mem. Torr. Club, **3**: Pt. 3, 5 (1893).

Sisymbrium pinnatum (Walt.) Greene, Pitt. **1**: 200 (1889).

Thelypodium linearifolium (A. Gray) S. Wats. Bot. King's Rep. 25 (1871).

Thelypodium longifolium (Benth.) S. Wats. King's Rep. **5**: 25 (1871).

Thelypodium micranthum (A. Gray) S. Wats. Proc. Am. Acad. **17**: 321 (1882).

Thlaspi alpestre L. Sp. Pl. Ed. 2, 903 (1763). Form with somewhat larger flowers than the type. It is *T. Fendleri* A. Gray, Pl. Wright. **2**: 14 (1853).

CAPPARIDACEÆ.

Cleome lutea Hook. Fl. Bor. Am. **1**: 70, *t. 25* (1830). Mrs. Hoyt, San Carlos.

CRASSULACEÆ.

Sedum Wrightii A. Gray, Pl. Wright. **1**: 76 (1852). Dr. Ebert, Tanner's Cañon; Dr. Wilcox, Ft. Huachuca.

SAXIFRAGACEÆ.

Fendlera rupicola Engelm. & Gray; A. Gray. Pl. Wright. **1**: 77, *t. 5* (1852). Mrs. Hoyt, Ft. Apache; Dr. Wilcox, Ft. Huachuca.

Heuchera sanguinea Engelm. Wisliz. Mem. Tour. N. Mex. 107 (1848). Dr. Wilcox, Ft. Huachuca; Dr. Ebert, Tanner's Cañon.

Philadelphus microphyllus A. Gray, Mem. Am. Acad. (II.) **4**: 54 (1849)?

The same as Fendler's No. 266, except that the upper leaf-surface is appressed-pubescent and the calyx-lobes are silky-villous without.

Ribes aureum Pursh, Fl. Am. Sept. 164 (1814). Mrs. Hoyt, Ft. Apache; Dr. Wilcox, Ft. Huachuca.

Ribes cereum Dougl. Trans. Hort. Soc. **7**: 512 (1830); Mrs. Hoyt, Ft. Apache.

PLATANACEÆ.

Platanus Wrightii S. Wats. Proc. Am. Acad. **10** : 349 (1875).

ROSACEÆ.

Agrimonia striata Michx. Fl. Bor. Am. **1** : 278 (1803). Mrs. Hoyt, Ft. Apache.

Cercocarpus breviflorus A. Gray, Pl. Wright. **2** ; 54 (1853)?

CERCOCARPUS PAUCIDENTATUS (S. Wats.) Britton.

C. parvifolius paucidentatus S. Wats. Proc. Am. Acad. **17** : 353 (1882).

Straggling shrub, branching from the base, sometimes fifteen feet high; bark dark gray, somewhat glaucous and often reddish when young; leaves clustered at the ends of short branches, which are scaly to the base with the scars of fallen leaves and are villous-pubescent when young; petiole short; blade thick, 15 to 20 mm. long and from $\frac{1}{3}$ to $\frac{1}{2}$ as wide, obovate, narrowly spatulate or elliptic, narrowed from about the middle to the acute or wedge-shaped base, usually somewhat narrowed towards the obtuse and mucronate or truncate apex, entire or with a few inconspicuous teeth towards the apex; margin inrolled, upper surface green, impressed above the veins, soft-pubescent, lower surface covered with a dense whitish tomentum; principal veins prominent on the under surface, forming a very small angle with the midrib, usually deflected upward as they approach the margin, villous with spreading silky hairs, lesser veins obscure; flowers much as in *C. parvifolius;* calyx-tube 5 to 8 mm. long in fruit; tail of achene 3 to 5 cm. long.

This plant is certainly a distinct species. In *C. parvifolius* the bark is usually of a lighter gray; the leaves thinner, less rigid, broadly obovate wedge-shaped, conspicuously serrate from about the middle upward, rounded or truncate at the broad apex, the upper surface less pubescent and less furroughed by the impression of the veins; the veins beneath less villous, much less prominent, forming a mucl greater angle with the midrib and not deflected upward as they approach the margin; the fruiting calyx-tube is about twice as long and proportionally wider, and the tail to the achene is twice as long or more. "The heart is as hard as ebony—is worked by a file, as it seems too hard for the plane. I have seen none more than fifteen feet high and six inches in diameter, usually less. Grows in clumps like the alder."—Wilcox. Appears to flower twice in the same season, in March—May, and again in August. Dr. Wilcox, Ft. Huachuca; Dr. Ebert, Tanner's Cañon. The common species in New Mexico and Arizona.

Cowania Mexicana D. Don, Trans. Linn. Soc. **14** : 575 (1825). Mrs. Hoyt, Ft. Apache; Dr. Wilcox, Ft. Huachuca.

Fallugia paradoxa (Don) Torr. Emory's Rep. 140 (1848).

Geum ciliatum Pursh, Fl. Am. Sept. 352 (1814). Mrs. Hoyt, Ft. Apache.

LUETKEA CÆSPITOSA ELATIOR (S. Wats.) Britton.

Spiræa cæspitosa elatior S. Wats. Bot. King's Rep. 81 (1871). Dr. Ebert, Tanner's Cañon.

Potentilla glandulosa Lindl. Bot. Reg. **19** : *t 1583* (1833)? Mrs. Hoyt, Ft. Apache.

Potentilla Thurberi A. Gray, Mem. Am. Acad. (II.) **5** : 318 (1855). Dr. Wilcox, Ft. Huachuca; Mrs. Hoyt, Ft. Apache.

Prunus salicifolia H.B.K. Nov. Gen. et Sp. **6**: 241 (1823).
Rosa Fendleri Crépin, Prim. Mon. Ros. Fasc. 4, 452 (1876).
RUBUS DELICIOSUS NEO-MEXICANUS (A. Gray) Kearney.
R. Neo-Mexicanus A. Gray, Pl. Wright, **2**: 55 (1853).
Leaves larger than in *R. deliciosus* Torr., more deeply 3-lobed, sometimes obscurely 5-lobed; pubescence of leaves, petioles and stems more villous; calyx and peduncles somewhat more glandular. Typical *R. deliciosus* is a more northern plant. Dr. Wilcox, Ft. Huachuca; Dr. Ebert, Tanner's Cañon.
Spiræa dumosa Nutt.; Torr. & Gray, Fl. N. Am. **1**: 416 (1840).

LEGUMINOSÆ.

Acacia constricta Benth.; A. Gray, Pl. Wright. **1**: 66 (1852).
A peculiar form (the same as 327b of the Mexican Boundary collection) with much reduced leaves on very short petioles, smaller heads on shorter peduncles and smaller spines, was also collected by Dr. Wilcox.
Acacia filicoides (Cav.) Trel.; Branner & Cov., Rep. Geol. Surv. Ark. (for 1888) **4**: 178 (1891).
Acacia Greggii A. Gray Pl. Wright. **1**: 65 (1852).
Acacia sp. Near *A. filicoides*, but larger in every way, the rachis of the leaf bearing prickles.
Acuan Jamesii (T. & G.) Kuntze, Rev. Gen. Pl. 158 (1891).
Amorpha fruticosa L. Sp. Pl. 713 (1753).
ANNESLEA ERIOPHYLLA (Benth.) Britton.
Calliandra eriophylla Benth.; Hook., Lond. Journ. Bot. **3**: 105 (1844).
ANNESLEA RETICULATA (A. Gray) Britton.
Calliandra reticulata A. Gray, Pl. Wright. **2**: 53 (1853).
Astragalus Arizonicus A. Gray, Proc. Am. Acad. **7**: 398 (1868). Mrs. Hoyt, Ft. Apache; Dr. Wilcox, Ft. Huachuca.
Astragalus Brandegei Porter; Porter & Coult. Fl. Col. 24 (1874). Mrs. Hoyt, Ft. Apache.
Astragalus mollissimus Torr. Ann. Lyc. N. Y. **2**: 178 (1828).
Astragalus scaposus A. Gray, Proc. Am. Acad. **13**: 366 (1878).
BRITTONAMRA SERICEA (A. Gray) Kearney.
Cracca Edwardsii sericea A. Gray, Proc. Am. Acad. **17**: 201 (1882).
Cracca sericea A. Gray, Proc. Am. Acad. **19**: 74 (1883–84).
Cassia bauhinioides A. Gray, Bost. Journ. Nat. Hist. **6**: 180 (1850).
Cassia calycioides DC.; Colladon, Hist. Cass. 125 (1816).
Cassia leptocarpa Benth., Linnæa **22**: 528 (1849).
Cassia Lindheimeriana Scheele, Linnæa **21**: 457 (1848).
Cologania longifolia A. Gray, Pl. Wright. **2**: 35 (1853).
Cracca leucantha (H.B.K.) Kuntze, Rev. Gen. Pl. 175 (1891).
Cracca purpurea L. Sp. Pl. 752 (1753).
Tephrosia tenella A. Gray, Pl. Wright. **2**: 36 (1853).
Crotalaria lupulina H.B.K. Nov. Gen. et Sp. **6**: 402 (1823).
C. pumila Orteg. Hort. Matr. 23 (1800)?
Crotalaria rotundifolia (Walt.) Poir. in Lam. Encycl. Suppl. **2**: 402 (1811)?
Root annual; leaves less rounded; raceme short-peduncled.
ERYTHRINA FLABELLIFORMIS Kearney.
E. coralloides A. Gray, Mem. Am. Acad. (II.) **5**: 301 (1855), not DC.
"Shrub or small tree, from five to ten feet high;" stems white with a minute velvety canescence when young; armed with stout,

slightly curved prickles about 6 mm. long, solitary below the axils of the leaves; leaves trifoliolate; petioles 6 to 8 cm. long, canescent when young and usually bearing 1 to 5 small recurved prickles; leaflets firm and thickish, 4 cm. to 6 cm. long, 4 to 7 cm. wide, usually broader than long, flabelliform or deltoid-ovate, rounded at apex, truncate or cuneate at base, the terminal on a petiolule 35 to 45 mm. long, the lateral on petiolules 5 to 8 mm. long, upper surface smooth, lower surface minutely pubescent, veins reticulated, conspicuous on both surfaces; flowers crowded in short terminal racemes, numerous, borne on short, velvety-canescent pedicels; calyx 8 to 9 cm. long, campanulate, truncate, usually somewhat oblique, white-tomentose; corolla bright scarlet, the vexillum alone projecting beyond the calyx, about 4 cm. long, linear-oblong, narrowed at both ends, straight or more usually somewhat falcate; stamens ten, filaments united the greater part of their length; legume linear, torose, narrowed at both ends, borne on a stipe about 3 cm. long, tipped with the persistent style for about the same length, minutely and densely tomentose; seeds oval, 10 to 15 mm. long, bright scarlet with a large whitish hilum.

Referred with hesitation to *E. coralloides* DC.* by Dr. Gray and by Torrey.† It differs, however, from the description in the Prodromus and from Mocino's figure (for a tracing of which we are indebted to the kindness of M. Casimir DeCandolle) in the presence of prickles on the petiole; in the shape and size of the leaflets, those of *E. coralloides* being ovate, rounded at base and acutish at apex, smaller and the petiolule of the terminal one shorter; in the much larger calyx; in the legume which is described by DeCandolle as smooth and which the figure represents with a shorter stipe and beak; and in the hilum of the seed, the margin of which is hardly black.

Galactia Wrightii A. Gray, Pl. Wright. **1**: 44 (1852).

G. tephrodes A. Gray, Pl. Wright. **2**: 34 (1853).

A careful comparison of the types and original descriptions of these two forms has led to the conclusion that they are not specifically distinct.

Glycyrrhiza lepidota Pursh, Fl. Am. Sept. 480 (1814). Mrs. Hoyt, Ft. Apache.

Hoffmanseggia Falcaria stricta (Benth.) Fisher, Contr. U. S. Nat. Herb. **1**: 144 (1892).

KUHNISTERA OCCIDENTALIS A. A. Heller.

Petalostemon candidus occidentalis A Gray, ined.

"Perennial, from a stout branching root; stem erect, branching, 1–2 ft. high, smooth; leaflets usually two pairs, oblong-linear, usually a half-inch or less in length, very narrow, thickly dotted beneath; heads short-peduncled, narrowly cylindrical, usually from two to four times as long as broad; bracts early deciduous, but rachis covered with filament-like bractlets; calyx tube smooth, the short triangular lanceolate green lobes ciliate; flowers white; ovary smooth, strongly keeled on the back.

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* Prodr. **2**: 413 (1825); Moc. & Sessé, Ic. Fl. Mex. *t. 253*, ined.

† Bot. Mex. Bound. Surv. 50 (1859).

Apparently growing in very dry ground, as all the specimens seen, ranging from Nebraska to Mexico, have the leaflets folded showing only the lower side. This is the *Petalostemon candidus* var. *occidentalis* Gray, on Pringle's labels, but never described nor published." Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

Lathyrus decaphyllus Pursh, Fl. Am. Sept. 471 (1814).
Lathyrus graminifolius (S. Wats.) White, Bull. Torr. Club, **21**: 454 (1894).
Lotus humistratus (Benth.) Greene, Pitt. **2**: 139 (1890).
Lotus mollis Greene, Pitt. **2**: 143 (1890).
Lotus puberulus (Benth.) Greene, Pitt. **2**: 142 (1890).
Lotus Wrightii (A. Gray) Greene, Pitt. **2**: 143 (1890).
Lupinus argenteus Pursh, Fl. Am. Sept. 468 (1814). Mrs. Hoyt, Ft. Apache.
Lupinus concinnus Agardh, Syn. Lup. 6 (1835).
Lupinus Sitgreavesii S. Wats. Proc. Am. Acad. **8**: 527 (1873).
Medicago denticulata Willd. Sp. Pl. **3**: 1414 (1803).
Meibomia batocaulis (A. Gray) Kuntze, Rev. Gen. Pl. 197 (1891).
Meibomia Neo-Mexicana (A. Gray) Kuntze, Rev. Gen. Pl. 198 (1891).
Mimosa acanthocarpa (Willd.) Benth. Hook. Journ. Bot. **4**: 409 (1842). ?
Mimosa biuncifera Benth. Pl. Hartweg. 12 (1839).?
Mimosa dysocarpa Benth.; A. Gray, Pl. Wright. **1**: 62 (1852).
Mimosa Grahami A. Gray, Pl. Wright. **2**: 52 (1853).
Mimosa Lindheimeri A. Gray, Bost. Journ. Nat. Hist. **6**: 181 (1850).
PAROSELA ALBIFLORA (A. Gray) A. M. Vail.
Dalea albiflora A. Gray, Pl. Wright. **2**: 38 (1853).
Parosela aurea (Nutt.) Britton, Mem. Torr. Club, **5**: 196 (1894).
PAROSELA FORMOSA (Torr.) A. M. Vail.
Dalea formosa Torr. Ann. Lyc. N. Y. **2**: 177 (1828). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
PAROSELA POGONATHERA (A. Gray) A. M. Vail.
Dalea pogonathera A. Gray, Mem. Am. Acad. (II.) **4**: 31 (1849).
PAROSELA RUBESCENS (S. Wats.) A. M. Vail.
Dalea rubescens S. Wats. Proc. Am. Acad. **17**: 369 (1881–82).
PAROSELA WISLIZENI (A. Gray) A. M. Vail.
Dalea Wislizeni A. Gray, Mem. Am. Acad. (II.) **4**: 32 (1849).
PHACA THURBERI (A. Gray) Kearney.
Astragalus Thurberi A. Gray, Mem. Am. Acad. (II.) **5**: 312 (1855).
Phaseolus atropurpureus Moc.; DC. Prodr. **2**: 395 (1825).
Phaseolus retusus Benth. Pl. Hartweg. 11 (1839).
Phaseolus rotundifolius A. Gray, Pl. Wright. **2**: 34 (1853).
Phaseolus Wrightii A. Gray, Pl. Wright. **1**: 43 (1852).
Prosopis juliflora (Sw.) DC. Prodr. **2**: 447 (1825).
Rhynchosia Texana Torr. & Gray, Fl. N. Am. **1**: 687 (1840). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
Robinia Neo-Mexicana A. Gray, Mem. Am. Acad. (II.) **5**: 314 (1855). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
Sophora sericea Nutt. Gen. **1**: 280 (1818).
Thermopsis montana Nutt.; Torr. & Gray, Fl. N. Am. **1**: 388 (1840). Mrs. Hoyt, Ft. Apache.
Trifolium involucratum Willd. Sp. Pl. **3**: 1372 (1803). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

What appears to be an abnormal form of this species with broader leaflets and involucre cleft almost to the base into linear segments, was collected by Dr. Wilcox near Ft. Huachuca.

Vicia linearis (Nutt.) Greene, Fl. Francis. 3 (1891). Mrs. Hoyt, Ft. Apache.

Vicia pulchella H.B.K. Nov. Gen. et Sp. **6**: 499. *t. 583* (1823).
Zornia diphylla reticulata Benth.; Mart. Fl. Bras. **15**: Pt. 1, 80. *t. 21, 22* (1870).

GERANIACEÆ.

Geranium cæspitosum James; Torr. Ann. Lyc. N. Y. **2**: 173 (1828).

OXALIDACEÆ.

Oxalis decaphylla H.B.K. Nov. Gen. et Sp. **5**: 238 (1821).
Oxalis divergens Benth. Pl. Hartweg. 9 (1839).
Oxalis Wrightii A. Gray, Pl. Wright. **1**: 27 (1852).

LINACEÆ.

Linum aristatum Engelm. Wisliz. Mem. Tour. N. Mex. 101 (1848).
Linum Lewisii Pursh, Fl. Am. Sept. 210 (1814).
Linum Neo-Mexicanum Greene; Coult. Bot. Gaz. **6**: 183 (1881).

MALPIGHIACEÆ.

Aspicarpa longipes A. Gray, Pl. Wright. **1**: 37 (1852).
Janusia gracilis A. Gray, Pl. Wright. **1**: 37 (1852). Mrs. Hoyt, San Carlos.

ZYGOPHYLLACEÆ.

Larrea Mexicana Moric. Pl. Nouv. Am. 71 (1833–46).
Tribulus grandiflorus (Torr.) S. Wats. Bibl. Ind. **1**: 149 (1878). Wilcox, Ft. Huachuca; Mrs. Hoyt, San Carlos.
Tribulus maximus L. Sp. Pl. 386 (1753). Mrs. Hoyt, San Carlos; Wilcox, Ft. Huachuca.

RUTACEÆ.

Ptelea angustifolia Benth. Pl. Hartweg. 9 (1839).

POLYGALACEÆ.

Krameria parvifolia Benth. Bot. Sulph. 6. *t. 1* (1844).
Leaves larger than in the ordinary form.
Polygala alba Nutt. Gen. **2**: 87 (1818).
Polygala hemipterocarpa A. Gray, Pl. Wright. **2**: 31 (1853).
Polygala puberula A. Gray, Pl. Wright. **1**: 40 (1852).

EUPHORBIACEÆ.

Acalypha Lindheimeri Muell. Arg. Linnæa, **34**: 47 (1865–66).
Croton corymbulosus Engelm.; Rothr. Bot. Wheeler Rep. 242 (1878).
Croton Texensis (Kl.) Muell. Arg. in DC. Prodr. **15**: Pt. 2, 692 (1862). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca; Ebert, San Carlos.
Euphorbia albomarginata Torr. & Gray, Pacif. R. R. Rep. **2**: 174 (1856).
Euphorbia bilobata Engelm.; Torr. Bot. Mex. Bound. 190 (1859).
Euphorbia campestris Cham. & Schlecht. Linnæa, **5**: 84 (1830).
Euphorbia cuphosperma Boiss. in DC. Prodr. **15**: Pt. 2, 73 (1862).
Euphorbia exstipulata Engelm.; Torr. Bot. Mex. Bound. 189 (1859).
Euphorbia hypericifolia L. Sp. Pl. 454 (1753).
Euphorbia schizoloba Engelm. Proc. Am. Acad. **5**: 173 (1862). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
Euphorbia serpyllifolia Pers. Syn. **2**: 14 (1807).
Jatropha macrorhiza Benth. Pl. Hartweg. 8 (1839).
Tragia stylaris Muell. Arg. in DC. Prodr. **15**: Pt. 2, 930 (1862). Mrs. Hoyt, Ft. Apache.

MALVACEÆ.

Abutilon parvulum A. Gray, Pl. Wright. **1**: 21 (1852). Ebert, San Carlos; Wilcox, Ft. Huachuca.
Anoda hastata Cav. Diss. **1**: 38, *t. 11, f. 2* (1785).
Hibiscus denudatus Benth. Bot. Sulph. 7. *t. 3* (1844).
Sida diffusa HBK. Nov. Gen. et Sp. **5**: 257 (1821).
Sida physocalyx A. Gray, Bost. Journ. Nat. Hist. **6**: 163 (1857).
Sida spinosa angustifolia (Lam.) Griseb. Fl. Brit. W. Ind. 74 (1859). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
Sphæralcea angustifolia (Cav.) Spach, Hist. Veg. **3**: 353 (1834).

GUTTIFERÆ.

Hypericum formosum HBK. Nov. Gen. et Sp. **5** : 196 (1821). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

TAMARICACEÆ.

Fouquiera splendens Engelm,; Wisliz. Mem. Tour. N. Mex. 98 (1848).

BIXACEÆ.

Amoreuxia Wrightii A. Gray, Pl. Wright. **2**: 26 (1853).

VIOLACEÆ.

Calceolaria verticillata (Ort.) Kuntze, Rev. Gen. Pl. 41 (1891).
Viola obliqua Hill, Hort. Kew. 316 (1769).

ANACARDIACEÆ.

Rhus glabra L. Sp. Pl. 265 (1753).
Rhus radicans L. Sp. Pl. 266 (1753). Wilcox, Ft. Huachuca; Ebert, Tanner's Cañon.
Rhus trilobata Nutt.; Torr. & Gray, Fl. N. Am. **1**: 219 (1838–40). Ebert, San Carlos; Wilcox, Ft. Huachuca.
Rhus virens Lindh.; A. Gray, Bost. Journ. Nat. Hist. 159 (1857). Ebert, Ft. Grant; Wilcox, Ft. Huachuca.

ACERACEÆ.

Acer grandidentatum Nutt.; Torr. & Gray, Fl. N. Am. **1**: 247 (1838–40).

SAPINDACEÆ.

Sapindus marginatus Willd. Enum. 432 (1809).

RHAMNACEÆ.

Ceanothus Fendleri A. Gray, Mem. Am. Acad. (II.) **4**: 29 (1849).
Ceanothus Greggii A. Gray, Pl. Wright. **2**: 28 (1853). Mrs. Hoyt, Ft. Apache.
Ceanothus integerrimus Hook. & Arn. Bot. Beech. 329 (1841).
Rhamnus Purshianus DC. Prodr. **2**: 25 (1825).
Zizyphus obtusifolia (Hook.) A. Gray, Ill. Gen. Am. **2**: 170, *t. 163* (1849).

VITACEÆ.

Parthenocissus quinquefolia (L.) Planch. in DC. Mon. Phan. **5**: Pt. 2, 447 (1887).
Vitis Arizonica Engelm.; Parry, Am. Nat. **2**: 268 (1875).

LOASACEÆ.

Mentzelia albicaulis Dougl.; Hook. Fl. Bor. Am. **1**: 222 (1833).
Mentzelia aspera L. Sp. Pl. 516 (1753).
Mentzelia Wrightii A. Gray, Mem. Am. Acad. (II.) **4**: 48 (1849). Wilcox, Ft. Huachuca; Mrs. Hoyt, Ft. Apache.

CACTACEÆ.*

Cactus radiosus Neo-Mexicanus (Engelm.) Coult.
Cereus dasyacanthus Engelm.
Cereus Fendleri Engelm.
Cereus pectinatus Engelm.
Cereus pectinatus armatus Poselg.
Cereus polyacanthus Engelm.
Cereus stramineus Engelm.
Echinocactus Wislizeni Lecontei Engelm.
Opuntia arborescens Engelm.
Opuntia arbuscula Engelm.
Opuntia leptocaulis vaginata (Engelm.) Coult.
Opuntia mesacantha Raf.
Opuntia Whipplei Engelm.
Opuntia Whipplei spinosior Engelm.

LYTHRACEÆ.

PARSONSIA WRIGHTII (A. Gray) Kearney.
Cuphea Wrightii A. Gray, Pl. Wright. **2** : 56 (1853).
Lythrum alatum linearifolium A. Gray, Bost. Jour. Nat. Hist. **6** : 188 (1857). Wilcox, Ft. Huachuca ; Mrs. Hoyt, Ft. Apache.

ŒNOTHERACEÆ.

Anogra albicaulis (Pursh) Britton, Mem. Torr. Club, **5**: 234 (1894).
CHAMISSONIA CONTORTA PUBENS (S. Wats.) Kearney *Œnothera contorta pubens* Cov. Contr. U. S. Nat. Herb. **4** : 104 (1893).
Epilobium adenocaulon perplexans Trel. 2d Ann. Rep. Mo. Bot. Gard. 96 (1891)? Wilcox, Ft. Huachuca; Ebert, Tanner's Cañon; Mrs. Hoyt, Ft. Apache.
Galpinsia Hartwegi (Benth.) Britton, Mem. Torr. Club, **5**: 236 (1894). Wilcox, Ft. Huachuca; Ebert, Tanner's Cañon.
Gaura coccinea Nutt. Gen. **1**: 249 (1818). Mrs. Hoyt, Ft. Apache; Wilcox, Huachuca.
Gaura parviflora Dougl.; Hook. Fl. Bor. Am. **1**: 208 (1833). Mrs. Hoyt, Ft. Apache.
Gaura suffulta Engelm.; A. Gray, Bost. Journ. Nat. Hist. **6**: 190 (1850).
Gaura villosa Torr. Ann. Lyc. N. Y. **2**: 200 (1828).
Lavauxia triloba (Nutt.) Spach, Hist. Veg. **4**: 367 (1835).
Meriolix serrulata (Nutt.) Walp. Rep. **2**: 79 (1843). Mrs. Hoyt, Ft. Apache.
Onagra biennis (L.) Scop. Fl. Carn. Ed. 2, **1**: 269 (1772).
Pachylophus cæspitosa (Nutt.) Raimann in Engler & Prantl, Nat. Pfl. **3**: Abt. 7, 215 (1893).
XYLOPLEURUM ROSEUM (Ait.) Raimann in Engler & Prantl, Nat. Pfl. **3**: Abt. 7, 214 (1893).
Œnothera rosea Ait. Hort. Kew. **2**: 3 (1789).
Zauschneria latifolia (Hook. f.) Greene, Pitt. **1**: 25 (1887).

* Determined by Mr. Edwin B. Uline.

ARALIACEÆ.

Aralia humilis Cav. Ic. **4**: 7, *t. 313* (1797).

UMBELLIFERÆ.

Caucalis microcarpa Hook & Arn. Bot. Beechey, 348 (1841). Mrs. Hoyt, Ft. Apache.

Cymopterus montanus purpurascens A. Gray, Ives' Rep. 15 (1861). Mrs. Hoyt, Ft. Apache.

Eryngium Wrightii A. Gray, Pl. Wright. **1**: 78 (1852).

CORNACEÆ.

Cornus stolonifera Michx. Fl. Bor. Am. **1**: 92 (1803). Mrs. Hoyt, Ft. Apache.

Garrya Wrightii Torr. Pacif. R. R. Rep. **4**: 136 (1856).

ERICACEÆ.

Arbutus Arizonica (A. Gray) Sargent, Gard. & Forest **4**: 317 (1891).

Arctostaphylos pungens HBK. Nov. Gen. et Sp. **3**: 278 (1818).

PRIMULACEÆ.

Androsace occidentalis Pursh, Fl. Am. Sept. 137 (1814).

Dodecatheon pauciflorum (Durand) Greene, Pitt. **2**: 72 (1890). Mrs. Hoyt, Ft. Apache.

OLEACEÆ.

Fraxinus Pennsylvanica Marsh. Arb. Am. 51 (1785).

Fraxinus velutinosa Torr. Emory Rep. 149 (1848).

Menodora scabra A. Gray, Am. Journ. Sci. (II.) **14**: 44 (1852). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

GENTIANACEÆ.

Erythræa calycosa Buckl. Proc. Acad. Phila. 1862, 7 (1862).

Gentiana microcalyx Lemmon; A. Gray, Proc. Am. Acad. **17**: 222 (1882).

Gentiana serrata Gunner, Fl. Norveg. 10 (1766). Mrs. Major Haskell, Tanner's Cañon.

APOCYNACEÆ.

Apocynum cannabinum L. Sp. Pl. 213 (1753). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

Macrosiphonia brachysiphon (Torr.) A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 83 (1878).

ASCLEPIADACEÆ.

Asclepias brachystephana Engelm.; Torr. Bot. Mex. Bound. 163 (1859).

Asclepias involucrata Engelm.; Torr. Bot. Mex. Bound. 163 (1859).

Asclepias longicornu Benth. Pl. Hartweg. 24 (1840).

Asclepias Mexicana Cav. Ic. **1**: 42, *t. 58* (1791).

Asclepias nummularia Torr. Bot. Mex. Bound. 163 (1859).

Asclepias quinquedentata A. Gray, Proc. Am. Acad. **12**: 71 (1876).

Asclepias speciosa Torr. Ann. Lyc. N. Y. **2**: 218 (1828). Mrs. Hoyt, Ft. Apache.

Asclepias tuberosa L. Sp. Pl. 217 (1753).

Asclepiodora decumbens (Nutt.) A. Gray, Proc. Am. Acad. **12**: 66 (1877) Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

Convolvulaceæ.

Convolvulus incanus Vahl, Symb. **3**: 23 (1794). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
Evolvulus Arizonicus A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 218 (1878).
Evolvulus lætus A. Gray, Proc. Am. Acad. **17**: 228 (1882).
Evolvulus sericeus discolor A. Gray, Syn. Fl. N. Am. Ed. 2, **2**: Pt. 1, 436 (1886).
Ipomœa coccinea L. Sp. Pl. 160 (1753).
Ipomœa costellata Torr. Bot. Mex. Bound. 49 (1859).
Ipomœa leptotoma Torr. Bot. Mex. Bound. 150 (1859).
Ipomœa longifolia Benth. Pl. Hartweg. 16 (1839).
Ipomœa Mexicana A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 210 (1878). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
Ipomœa muricata Cav. Ic. **5**: 52, t. 478, f. 2 (1799).
Ipomœa Thurberi A. Gray. Whole plant sparsely hairy.

Cuscutaceæ.

Cuscuta Californica longiloba Engelm. Trans. St. Louis Acad. Sci. **1**: 498 (1860).
Cuscuta indecora Choisy, Cusc. 182, *t. 3, f. 3* (1841). Mrs. Hoyt, San Carlos.

Polemoniaceæ.

Gilia aggregata (Pursh) Spreng. Syst. **1**: 626 (1825).
Gilia floccosa A. Gray, Proc. Am. Acad. **8**: 272 (1870). Mrs. Hoyt, San Carlos; Wilcox, Huachuca.
Gilia floribunda A. Gray, Proc. Am. Acad. **8**: 267 (1870). Mrs. Hoyt, Ft. Apache.
Gilia gracilis Hook. Bot. Mag. *t. 2924* (1829). Mrs. Hoyt, Ft. Apache.
Gilia inconspicua sinuata (Dougl.) A. Gray, Proc. Am. Acad. **8**: 278 (1870). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
Gilia longiflora (Torr.) Don, Gard. Dict. **4**: 245 (1838). Mrs. Hoyt, San Carlos.
Gilia Thurberi A. Gray, Proc. Am. Acad. **17**: 223 (1882). Wilcox, Ft. Huachuca; Ebert, Tanner's Cañon.
Linanthus aureus (Nutt.) Greene, Pitt. **2**: 257 (1892). Mrs. Hoyt, Fort Apache, San Carlos.
Phlox speciosa Woodhousei A. Gray, Proc. Am. Acad. **8**: 256 (1870). Mrs. Hoyt, Ft. Apache.

Hydrophyllaceæ.

Phacelia heterophylla Pursh, Fl. Am. Sept. **1**: 140 (1814). Mrs. Hoyt, Ft. Apache.

Boraginaceæ.

Amsinckia echinata A. Gray, Proc. Am. Acad. **10**: 54 (1875).
Amsinckia spectabilis Fisch. & Mey. Ind. Sem. Hort. Petrop. **2**: 26 (1836).
Heliotropium phyllostachyum Torr. Bot. Mex. Bound, 137 (1859).
Lappula Texana (Scheele) Britton, Mem. Torr. Club **5**: 273 (1894). Wilcox, Ft. Huachuca. Mrs. Hoyt, Ft. Apache.
Lithospermum angustifolium Michx. Fl. Bor. Am. **1**: 130 (1803).
Lithospermum Cobrense Greene, Coult. Bot. Gaz. **6**: 157 (1881).
Onosmodium Thurberi A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 205 (1878). Mrs. Hoyt, Ft. Apache.
Oreocarya suffruticosa (Torr.) Greene, Pitt. **1**: 57 (1887). Mrs. Hoyt, Ft. Apache.

BERBENACEÆ.

Lippia Wrightii A. Gray; Torr. Bot. Mex. Bound. 126 (1859). Dr. Ebert, Ft. Grant.

Verbena bipinnatifida Nutt. Journ. Acad. Phila. **2**: 123 (1821). Wilcox, Ft. Huachuca; Mrs. Hoyt, Ft. Apache.

Verbena bracteosa brevibracteata A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 336 (1878). Mrs. Hoyt, Ft. Apache.

Verbena cancescens HBK. Nov. Gen. et. Sp. **2**: 274, *t. 136* (1817). Ebert, San Carlos; Wilcox, Huachuca.

Verbena polystachya HBK. Nov. Gen. et. Sp. **2**: 274 (1817).

Verbena remota Benth. Pl. Hartweg. 21 (1839).

LABIATÆ.

Clinopodium vulgare L. Sp. Pl. 587 (1753). Mrs. Hoyt, Ft. Apache.

Dracocephalum parviflorum Nutt. Gen. **2**: 35 (1818). Mrs. Hoyt, Ft. Apache.

Hedeoma hyssopifolia A. Gray, Proc. Am. Acad. **11**: 96 (1875). Wilcox, Ft. Huachuca; Ebert, San Carlos.

Hedeoma plicata Torr. Bot. Mex. Bound. 130 (1859).

Mentha Canadensis L. Sp. Pl. 577 (1753). Mrs. Hoyt, Ft. Apache.

Monarda citriodora Cerv.; Lag. Nov. Gen. et Sp. 2 (1816).

Monarda scabra Beck, Am. Journ. Sci. **10**: 260 (1826). Mrs. Hoyt, Ft. Apache.

Salvia Lemmoni A. Gray, Proc. Am. Acad. **20**: 309 (1885).

Salvia subincisa Benth. Pl. Hartweg. 20 (1839).

Scutellaria resinosa Torr. Ann. Lyc. N. Y. **2**: 232 (1828).

Stachys coccinea Jacq. Hort. Schoenb. **3**: 18, *t. 284* (1798).

Tetraclea Coulteri A. Gray, Am. Journ. Sci. (II.) **16**: 98 (1853).

Teucrium occidentale A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 349 (1878). Mrs. Hoyt, Ft. Apache.

Trichostema Arizonicum A. Gray, Proc. Am. Acad. **8**: 371 (1872).

SOLANACEÆ.

Chamæsaracha Coronopus (Dunal) A. Gray, Bot. Calif. **1**: 540 (1876). Mrs. Hoyt, Ft. Apache.

Datura meteloides DC. Prodr. **13**: Pt. 1, 544 (1852).

Lycium pallidum Miers, Ill. S. Am. Pl. **2**: 108, t. 67 (1849–57).

Margaranthus solanceus Schlecht. Hort. Hal. Fasc. 1, 1 (1841).

Physalis Fendleri A. Gray, Proc. Am. Acad. **10**: 66 (1875).
Unusually tall, leaves unusually large.

Solanum eleagnifolium Cav. Ic. **3** : 22, *t. 243* (1794). Mrs. Hoyt, San Carlos; Wilcox, Ft. Huachuca.

Solanum Jamesii Torr. Ann. Lyc. N. Y. **2** : 227 (1827).

Solanum nigrum Douglasii (Dunal) A. Gray, Bot. Calif. **1** : 538 (1876).

Solanum Fendleri A. Gray, Am. Journ. Sci. (II.) **22** : 285 (1856–7).
S. tuberosum var. *boreale* A. Gray, Syn. Fl. N. Am. **2** : Pt. 1, 227 (1878).

SCROPHULARIACEÆ.

Castilleia integra A. Gray; Torr. Bot. Mex. Bound. 119 (1859). Ebert, Tanner's Cañon; Wilcox, Ft. Huachuca.

Gerardia Wrightii A. Gray; Torr. Bot. Mex. Bound. 118 (1859).

Linaria Canadensis (L.) Dumont, Bot. Cult. **2** : 96 (1802).

Maurandia antirrhiniflora (Poir.) Willd. Hort. Berol. *t. 83* (1816). Ebert, San Carlos.
Mimulus guttatus DC. Cat. Monsp. 127 (1813).
Mimulus Lewisii Pursh, Fl. Am. Sept. 427 (1814).
Mimulus rubellus A. Gray; Torr. Bot. Mex. Bound. 116 (1859).
Orthocarpus purpurascens Palmeri A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 300 (1878).
Pedicularis centranthera A. Gray; Torr. Bot. Mex. Bound. 120 (1859). Mrs. Hoyt, Ft. Apache.
Pentstemon barbatus (Cav.) Nutt. Gen. **2**: 53 (1818). Wilcox, Ft. Huachuca; Mrs. Hoyt, San Carlos.
Pentstemon dasyphyllus A. Gray; Torr. Bot. Mex. Bound. 112 (1859).
Pentstemon spectabilis Thurber; A. Gray, Pacif. R. R. Rep **4**: 119 (1856). Form with corolla minutely glandular-puberulent. Mrs. Hoyt, Ft. Apache.
Pentstemon stenophyllus A. Gray; Torr. Bot. Mex. Bound. 112 (1859).
Veronica Americana Schwein.; Benth. in DC. Prodr. **10**: 468 (1846). Mrs. Hoyt, Ft. Apache.
Veronica peregrina L. Sp. Pl. 14 (1753).

OROBANCHACEÆ.

Orobanche Ludoviciana Nutt. Gen. **2**: 58 (1818). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

BIGNONIACEÆ.

Chilopsis linearis (Cav.) DC. Prodr. **9**: 227 (1845).

ACANTHACEÆ.

Anisacanthus Thurberi (Torr.) A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 328 (1878).
Calophanes decumbens A. Gray, Syn. Fl. N. Am. **2**: Pt. 1, 325 (1878). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

PLANTAGINACEÆ.

Plantago Purshii R. & S. Syst. **3**: 120 (1818). Wilcox, Ft. Huachuca; Mrs. Hoyt, Ft. Apache.

RUBIACEÆ.

Bouvardia triphylla Salisb. Parad. Lond. *t. 88* (1807).
Diodia teres angustata A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 35 (1884).
Galium asperrimum A. Gray, Mem. Am. Acad. (II.) **4**: 60 (1849).
Galium Wrightii A. Gray, Pl. Wright, **1**: 80 (1852).
Houstonia Wrightii A. Gray, Proc. Am. Acad. **17**: 202 (1882). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.

CAPRIFOLIACEÆ.

Lonicera albiflora Torr. & Gray, Fl. N. Am. **2**: 6 (1841–43). Ebert, Tanner's Cañon.
Lonicera ciliosa (Pursh) Poir. in Lam. Encycl. Suppl. **5**: 612 (1817).
Sambucus Mexicana Presl; DC. Prodr. **4**: 322 (1830).

VALERIANACEÆ.

Valeriana Arizonica A. Gray, Proc. Am. Acad. **19**: 81 (1883). Mrs. Hoyt, Ft. Apache.

Campanulaceæ.

Lobelia splendens Willd. Hort. Berol. *t. 86* (1816).
Lobelia fenestralis Cav. Ic. **6** : 8, *t. 512* (1801).

Cucurbitaceæ.

Apodanthera undulata A. Gray, Pl. Wright, **2** : 60 (1853).
Cucurbita fœtidissima HBK. Nov. Gen. **2** : 123 (1817) ?

Compositæ.

Achillea Millefolium L. Sp. Pl. 899 (1753). Mrs. Hoyt, Ft. Apache.
Actinella biennis A. Gray, Proc. Am. Acad. **13** : 373 (1878).
Agoseris heterophylla (Nutt.) Greene, Pitt. **2** : 178 (1891).
Ambrosia psilostachya DC. Prodr. **5** : 526 (1836).
Antennaria dioica (L.) Gaertn. Fruct. et Sem. **2** : 410 (1791). Mrs. Hoyt, Ft. Apache ; Wilcox, Ft. Huachuca.
Aplopappus laricifolius A. Gray, Pl. Wright. **2** : 80 (1853).
Artemisia Ludoviciana Nutt. Gen. **2** : 143 (1818). A small-leaved form, same as Wright's No. 1276 from New Mexico.
Aster ericæfolius tenuis A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 198 (1884). Mrs. Hoyt, San Carlos ; Wilcox, Ft. Huachuca.
Aster exilis Ell. Sk. **2** : 344 (1824).
Aster Lemmoni A. Gray, Syn. Fl. N. Am. **1** : Pt. 2, 199 (1884).
Aster multiflorus Ait. Hort. Kew. **3** : 203 (1789).
Aster tanacetifolius HBK. Nov. Gen. et Sp. **4** : 95 (1820).
Baccharis Bigelovii A. Gray ; Torr. Bot. Mex. Bound. 84 (1859).
Baccharis glutinosa Pers. Syn. **2** : 425 (1807).
Baccharis ramulosa (DC.) A. Gray, Mem. Am. Acad. (II.) **5** : 301 (1855).
Bahia absinthifolia dealbata A. Gray, Pl. Wright. **1**: 121 (1852).
Bahia dissecta (A. Gray) Britton, Trans. N. Y. Acad. Sci. **8**: 68 (1889).
Baileya pleniradiata Harv. & Gray ; A. Gray, Mem. Am. Acad. (II.) **4**: 105 (1849).
Baileya pleniradiata multiradiata (Harv. & Gray) Kearney.
B. multiradiata Harv. & Gray ; A. Gray, Mem. Am. Acad. (II.) **4** : 106 (1849).
B. multiradiata var. *nudicaulis* A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 318 (1884).
Berlandiera lyrata Benth. Pl. Hartweg. 17 (1839).
Berlandiera lyrata macrophylla A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 243 (1884).
Smaller leaved than the type of the variety, the leaves spatulate-oblong, obtuse and crenulate, some of them lyrate at the base.
Bidens Bigelovii A. Gray ; Torr. Bot. Mex. Bound. 91 (1859).
Bidens tenuisecta A. Gray, Mem. Am. Acad. (II.) **4**: 86 (1849).
Carduus Neo-Mexicanus (A. Gray), Greene, Proc. Acad. Sci. Phila. 1892, 362 (1893).
Carduus ochrocentrus (A. Gray), Greene, Proc. Acad. Sci. Phila. 1892, 363 (1893).
Carduus Rothrockii (A. Gray), Greene, Proc. Acad. Sci. Phila. 1892, 363 (1893) ?
Carminatia tenuiflora DC. in Deless. Ic. Sel. **4**: 42, *t. 98* (1839).
Carphochæte Bigelovii A. Gray, Pl. Wright, **1**: 89 (1852).

Centaurea Americana Nutt. Journ. Acad. Phila. **2**: 117 (1821).
Chrysopsis Rutteri (Rothr.) Greene, Erythea **2**: 96 (1894).
Coleosanthus betonicæfolius (A. Gray) Kuntze, Rev. Gen. Pl. 328 (1891).
Coleosanthus floribundus (A. Gray), Kuntze, Rev. Gen. Pl. 328 (1891).
Coleosanthus simplex (A. Gray), Kuntze, Rev. Gen. Pl. 328 (1891).
Coleosanthus squamulosus (A. Gray) Kuntze, Rev. Gen. Pl. 328 (1891).
COLEOSANTHUS WRIGHTII (A. Gray) Britton.
Brickellia Wrightii A. Gray, Pl. Wright. **2**: 72 (1853).
C. Californicus Wrightii Kuntze, Rev. Gen. Pl. 328 (1891). Wilcox, Ft. Huachuca; Ebert, Tanner's Cañon.
Cosmos parviflorus (Willd.) H.B.K. Nov. Gen. et Sp. **4**: 241 (1820).
Crassina grandiflora (Nutt.) Kuntze, Rev. Gen. Pl. 331 (1891).
Crassina pumila (A. Gray) Kuntze, Rev. Gen. Pl. 331 (1891).
Erigeron asper Nutt. Gen. **2**: 147 (1818).
Erigeron Bellidiastrum Nutt. Trans. Am. Phil. Soc. (II.) **7**: 307 (1841).
Erigeron Canadensis L. Sp. Pl. 863 (1753).
Erigeron concinnus (H. & A.) Torr. & Gray, Fl. N. Am. **2**: 174 (1841–43). Mrs. Hoyt, Ft. Apache.
Erigeron flagellaris A. Gray, Mem. Am. Acad. (II.) **4**: 68 (1849). Mrs. Hoyt, Ft. Apache; Wilcox, Huachuca.
Erigeron macranthus Nutt. Trans. Am Phil. Soc. (II.) **7**: 310 (1841).
Erigeron Neo-Mexicanus A. Gray, Proc. Am. Acad. **19**: 2 (1883).
Eriocarpum gracile (Nutt.) Greene, Erythea, **2**: 109 (1894).
Eriocarpum spinulosum (Pursh) Greene, Erythea. **2**: 108 (1894).
Eupatorium occidentale Arizonicum A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 101 (1884).
E. ageratifolium var. (?) *herbaceum* A. Gray, Pl. Wright. **2**: 74 (1853). We do not take up the older name of this plant because we suspect it to be specifically distinct from the *E. occidentale* of Hooker.
Eupatorium purpureum L. Sp. Pl. 838 (1753). Mrs. Hoyt, Ft. Apache.
Eupatorium Wrightii A. Gray, Pl. Wright. **1**: 87 (1852).
Flourensia cernua DC. Prodr. **5**: 593 (1836).
Leaves pellucid-punctate.
Gaertneria tenuifolia (A. Gray) Kuntze, Rev. Gen. Pl. 339 (1891).
Gaillardia Arizonica A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 353 (1884). Wilcox, Ft. Huachuca; Mrs. Hoyt, Ft. Apache.
Gaillardia pinnatifida Torr. Ann. Lyc. N. Y. **2**: 214 (1828).
Gaillardia pulchella Foug. Mém. Acad. Sci. Par. 1786, 5 (1788). Mrs. Hoyt, San Carlos.
Gnaphalium Sprengelii Hook. & Arn. Bot. Beech. 150 (1841).
Gutierrezia Sarothræ (Pursh) Britton & Rusby, Trans. N. Y. Acad. Sci. **7**: 10 (1887–88).
Gymnolomia multiflora (Nutt.) Benth. & Hook.; Rothr., Wheeler Rep. 160 (1878).
Gymnolomia triloba A. Gray, Proc. Am. Acad. **17**: 217 (1882).
Helenium Thurberi A. Gray, Proc. Am. Acad. **19**: 32 (1883).
Helianthus petiolaris Nutt. Journ. Acad. Phila. **2**: 115 (1821).
Heliopsis parvifolia A. Gray, Pl. Wright, **2**: 86 (1853).
Heterosperma pinnata Cav. Ic. **3**: 34, *t. 267* (1794).
Hieracium carneum Greene; Coult. Bot. Gaz. **6**: 184 (1881).
Hieracium Fendleri discolor A. Gray, Proc. Am. Acad. **19**: 69 (1883). Mrs. Hoyt, Ft. Apache.
Hymenopappus flavescens A. Gray, Mem. Am. Acad. (II.) **4**: 97 (1849).
Hymenothrix Wislizeni A. Gray, Mem. Am. Acad. (II.) **4**: 102 (1849).

Hymenothrix Wrightii A. Gray, Pl. Wright. **2** : 97 (1853).
Kuhnia rosmarinifolia Vent. Hort. Cels. *t. 91* (1800).
Leucampyx Newberryi A. Gray ; Port. & Coult. Fl. Col. 77 (1874).* Mrs. Hoyt, Ft. Apache.
Malacothrix Fendleri A. Gray, Pl. Wright. **2** : 104 (1853). Wilcox, Ft. Huachuca ; Mrs. Hoyt, Ft. Apache.
Malacothrix glabrata (Eaton) A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 422 (1884).
Melampodium cinereum DC. Prodr. **5**: 518 (1836).
Melampodium hispidum H.B.K. Nov. Gen. et Sp. **4**: 273, *t. 399* (1820).
Microseris linearifolia (DC.) A. Gray, Proc. Am. Acad. **9**: 211 (1874).
Pectis filipes Harv. & Gray; A. Gray, Mem. Am. Acad. (II.) **4**: 62 (1849).
Pectis imberbis A. Gray, Pl. Wright. **2**: 70 (1853).
Pectis longipes A. Gray, Pl. Wright. **2**: 69 (1853).
Pectis prostrata Cav. Ic. **4**: 12, *t. 324* (1797).
Perityle coronopifolia A. Gray, Pl. Wright. 2: 82 (1853).
Perezia nana A. Gray, Mem. Acad. (II.) **4**: 111 (1849).
Perezia Wrightii A. Gray, Pl. Wright. **1**: 127 (1852). Mrs. Hoyt, Ft. Apache.
Ptiloria Thurberi (A. Gray) Greene, Pitt. **2**: 133 (1890). Mrs. Hoyt, Ft. Apache; Wilcox, Huachuca.
Rudbeckia columnaris Pursh, Fl. Am. Sept. 575 (1814). Mrs. Hoyt, Ft. Apache.
Rudbeckia laciniata L. Sp. Pl. 906 (1753). Mrs. Hoyt, Ft. Apache; Wilcox, Ft. Huachuca.
Sanvitalia Aberti A. Gray, Mem. Am. Acad. (II.) **4**: 87 (1849).
Schkuhria Wrightii A. Gray, Pl. Wright. **2**: 95 (1853).
Senecio Douglasii DC. Prodr. **6**: 429 (1837).
Senecio Hartwegi Benth. Pl. Hartweg. 18 (1840).
Senecio Neo-Mexicanus A. Gray, Proc. Am. Acad. **19**: 55 (1883). Mrs. Hoyt, Ft. Apache ; Wilcox, Ft. Huachuca.
Senecio Toluccanus microdontus A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 388 (1884). Mrs. Hoyt, Ft. Apache.
Solidago Bigelovii A. Gray, Proc. Am. Acad. **16**: 80 (1880).
Solidago Canadensis canescens A. Gray, Proc. Am. Acad.. **17**: 197 (1882). Wilcox, Ft. Huachuca; Ebert, Tanner's Cañon.
Sonchus asper Vill. Hist. Pl. Dauph. **3**: 158 (1789).
Stevia serrata Cav. Ic. **4**: 33, *t. 355* (1797).
Stylocline micropodoides A. Gray, Pl. Wright. **2**: 84 (1853).
Thelesperma gracile (Torr. & Gray) A. Gray, Pl. Wright. **1**: 109 (1852). Mrs. Hoyt, Ft. Apache; Wilcox. Ft. Huachuca.
Townsendia Rothrockii A. Gray; Rothr., Wheeler Rep. **6**: 148 (1878). Mrs. Hoyt, Ft. Apache.
Verbesina encelioides (Cav.) A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 288 (1884).
Viguiera cordifolia A. Gray, Pl. Wright. **1**: 107 (1852).
Viguiera helianthoides HBK. Nov. Gen. et. Sp. **4**: 226 (1820).
Xanthocephalum Benthamianum Hemsl. Bot. Centr. Am. **2**: 110 (1881–82). New to the United States.
Xanthocephalum gymnospermoides B. & H. Gen. Pl. **2**: 249 (1873).
Xanthocephalum Wrightii A. Gray, Proc. Am. Acad. **8**: 632 (1873).
Zexmenia podocephala A. Gray, Syn. Fl. N. Am. **1**: Pt. 2, 286 (1884).

* See Bull. Torr. Club **21** : 82 (1894).

Prof. E. B. Wilson in the following paper summarized the results of his summer's research in the fertilization of echinoderms. In his observations on the egg of the sea urchin, *Toxopneustes variegatus*, the fertilizing sperm was found to enter the egg *at any point*, the first plane of cleavage always passing through the point of the sperm's contact with the egg surface. The embryonic axis does not coincide with the original egg axis, but may form any angle with it. A second result indicates with the utmost probability that the observations of Fol must be looked upon as untrustworthy, and that no quadrille of the centrosomes occurs.

Dr. Bashford Dean gave an account of the "Breeding habits of *Lepidosteus*," a report on his visit to Black Lake, N. Y. (May, 1894), in company with Prof. E. B. Wilson. By artificial fertilization a complete series of developmental stages was secured. The results of a study of the earlier development point to closer relationship with elasmobranchs than has hitherto been believed.

Prof. H. F. Osborn reported to the Academy on the Oxford meeting of the British Association. The proceedings of the Biological Section were summarized and notes were given on the present character of the researches of the English workers, and on the conservative attitude of their evolutionists in regard to natural selection.

Capt. T. L. Casey exhibited a Californian hairless mouse, and referred it to the chairman for determination.

The annual election of Sectional officers was then taken up. Prof. N. L. Britton was elected Chairman, and Bashford Dean, Secretary.

In resigning the Chairmanship, Professor Osborn briefly addressed the meeting upon the work of the past two years, and the future outlook. He pointed out that the general object in establishing the Section was to bring together workers in all departments of Biology for the presentation and discussion of such results of their researches as were of general interest and value. The Section is therefore not in any sense a rival of any of the useful existing biological societies of a more special character; on the contrary, it is animated by the belief that all have certain common ground. The subjects of the papers which have been presented to the Section during the past two years give sufficient evidence of the broad field covered,—namely, of Botany, General Zoölogy, as well as Icthyology, Cytology, Comparative Neurology, Vertebrate Palæontology, Physiology, Human and Comparative Anatomy. The general problems of Evolution and Heredity have also been discussed, especially in the notable meeting between Professor Poulton of Oxford and Professor E. D. Cope of Philadelphia. The promise for the future is that this field will be enlarged by the addition of Bacteriology and Micro-Photography. The policy has been established of considering several short papers upon different branches of biology each evening, including only points of main interest and guarded by a time limit. The outlook for the future work of the Section is bright. With the rapid increase of biological investigation in this city contributions to the Section promise to be even more interesting and numerous than heretofore.

The following Sectional Committee was appointed: Chairman *ex-officio*, Secretary *ex-officio*, Prof. F. S. Lee, Mr. C. F. Cox, Prof. H. F. Osborn.

Dr. Bolton then read a short paper on the subject of the perpetuation of the names of distinguished men of science by the municipal government of Paris, in the nomenclature of the streets of that city, a large number of which commemorate the names of authors, investigators and artists in all branches of science, literature and art, not only of France, but of all nations. He emphasized the stimulus that this recognition gave to intellectual activity in all branches of learning, and to the good results that would follow the introduction of the same system in New York and other American cities, where, although presidents and generals are thus honored, scientists, artists and writers are passed by.

Meeting adjourned.

BASHFORD DEAN,
Recording Secretary of Biological Section.

J. F. KEMP,
Recording Secretary.

October 29th, 1894.

The Academy met and listened to the first public lecture of the course for 1894–'95, by Prof. J. F. Kemp, on the *Mesabi Iron Range of Minnesota*, illustrated by specimens and lantern views.

J. F. KEMP,
Recording Secretary:

November 5th, 1894.

REGULAR BUSINESS MEETING.

The Academy was called to order by President Rees, but as no quorum for the transaction of business was present the business meeting was adjourned one week.

The section of Astronomy and Physics then organized, President Rees continuing in the chair, eight persons present.

The minutes of the previous meeting were read and approved.

The paper of the evening was then read by Prof. A. M. Mayer, "On the production of beats and beat-tones by two vibrating bodies, whose frequencies of vibration are so great as to surpass the limit of audibility."

Prof. Mayer outlined the discussion as to whether such interference tones were subjective or objective, maintaining that they have an actual physical existence. In the attempt to prove the objective existence of these tones it was desired to produce difference-tones from two notes which are both inaudible by reason of their very high pitch. Earlier attempts were with rectangular bars, which, when struck on the corner, vibrate at one rate in one transverse direction and at another in the transverse direction perpendicular to the first. These difference-tones only last a *very* short time, and for this reason the method was abandoned. On taking up the subject again he was able, with specially constructed whistles, to hear the difference-tone produced by two whistles, the notes of both being too high to be heard when sounded alone. König, of Paris, has now made a set of forks, which individually are inaudible, and yet their difference-tones are audible.

The paper was discussed by Professors Pupin, Rees and Hallock.

The Section then adjourned. WM. HALLOCK

Recording Secretary of Section.

STATED MEETING.

November 12th, 1894.

Thirty-five persons present, President J. K. REES in the chair.

The following new members were elected:

Prof. Dr. BOHUSLAV BRAUNER, Corresponding Member.

JOHN JACOB ASTOR, Resident Member.

J. C. PFISTER, Resident Member.

A motion was carried granting to the council power to make the needful arrangements for the second annual reception. In support of this measure, Prof. H. F. Osborn spoke, calling attention to the success of the last reception and urging the importance of an annual meeting which should serve the function of the conversazione of the Royal Society.

The Biological Section then organized with Prof. Britton in the chair.

The following notes and papers were presented:

Prof. N. L. Britton, "Notes on some problems in plant evolution." The central position of algæ was emphasized on palæontological grounds; pteridophytes suggesting an advancing phytum of early palæozoic origin; bryophytes a late one. The origin of angiosperms becomes more obscure in the failure in transitional types of the plants of the Portuguese lower cretaceous.

G. N. Calkins, "A little known phenomenon in the life history of *Stentor*." Free swimming embryos of *S. cæruleus* were noted, which were called by Bütschli (Cf. Brown, *Protozoa*) *Lieberkuhnina*. The observations of Claparède and Lachman on *Stentor roeselii* were thus corroborated.

The following paper was then read:

ADDITIONAL NOTES ON THE CLASSIFICATION OF LEPIDOPTEROUS LARVÆ.

By Harrison G. Dyar, A. M.

In a former communication to this Academy, I attempted to found a classification of lepidopterous larvæ on the arrangement and modification of their tubercles; but I excluded from consideration the first larval stage. I propose to consider this stage now, and offer also a few supplementary notes.

THE LARVAL PROLEGS.

Prof. J. B. Smith has called my attention again to the arrangement of the crotchets on the abdominal feet of larvæ as classificatory characters of importance. But I do not find that they show as much as the tubercles. It is characteristic of concealed feeders to have the crotchets in a circle. and this structure has been retained in the Cossina as here defined. It has not been regained in those Noctuids which live concealed (*e. g.*, *Achatodes zeæ*), but the character is not exclusive, since some pyralids have the ring incomplete (*e. g.*, *Mecyna reversalis*), and the Drepanidæ have a complete circle of crotchets.* Thus this

* See Packard. Proc. Boston Soc. Nat. Hist., xxiv., 484 (1890). The same condition is found in the feet of *Falcaria bilineata*.

character is not an "absolute diagnosis of Macro-Heterocera," as Dr. Chapman states it to be,† at least not in the form in which it has been presented. Probably a careful study of these structures would tend to elucidate the phylogeny of the lepidopterous families, as in the case of any other series of characters; but I am of the opinion that the subject is here more difficult, more obscured by special adaptations, than in the case of the larval tubercles.

Suborder JUGATEÆ.

Through the kindness of Dr. T. A. Chapman, I have received the larva of *Micropteryx purpurella* from England. The ar-

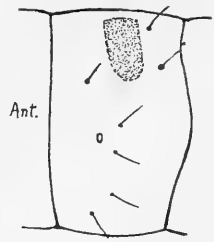

FIG. 1. A SEGMENT OF MICROPTERYX PURPURELLA.

rangement of its setæ is shown in the figure (Fig. 1). These correspond quite well with those of *Hepialus*, except that the four on the base of the leg are absent; but this species of *Mi-*

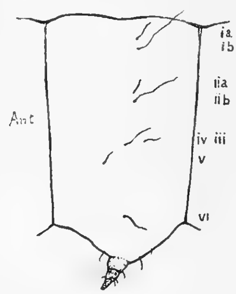

FIG. 2. A THORACIC SEGMENT OF COSSUS COSSUS, TYPICAL OF ALL FRENATÆ.

cropteryx has no legs. It has a double dorsal shield on every segment, which may account for the unusually posterior posi-

† Trans. Ent. Soc. London, 1893, p. 106.

tion of tubercle i. Micropteryx and Hepialus both further differ from the Frenatæ in lacking the peculiar arrangement of tubercles on the thoracic segments which is uniform throughout that suborder (Fig. 2).

In the absence of full material, I do not like to insist strongly on the the characters of the Jugatæ as defined by the arrangement of the larval tubercles, though the species which I have examined indicate that the characters are well marked.

We have now the Jugatæ and Frenatæ separated by good characters of venation, by the vestiture of the wings* and the larval tubercles. It is to be hoped that Dr. Chapman may yet find pupal characters which point in the same direction.†

Suborder FRENATÆ.

During the past season I have collected the newly hatched larvæ of several families of this suborder, to determine the relations of the tubercles in the first stage and especially to see what light, if any, was thrown on the classification of the larvæ by this embryonic condition. In my former paper I excluded this stage from consideration on account of its generalized condition; but it is evident that a consideration of it would throw light on the phylogenitic relationships of the more specialized families. This was especially desirable in the case of the Sphingidæ.

I may say at once that my former conclusions are confirmed except in the case of the Saturnina. In this group, I find that I have misinterpreted the arrangement of the tubercles of the mature larva in two instances, one of which is important. From the newly hatched larva, it appears that the single process or wart below the spiracle is derived from tubercles iv. and v. consolidated, instead of from v. alone, iv. having disappeared as I supposed. The structure is, therefore, the same as in the Generalized Frenatæ, not that of the Specialized Frenatæ. This conclusion is extremely interesting, as it tends to remove the only serious contradiction between my classification of the larvæ and Prof. J. H. Comstock's one of the moths. It will be remembered that I placed the Lacosomidæ among the Generalized Frenatæ, while Prof. Comstock placed them among the Saturnina. The change which I must make in the position which I have assigned to the Saturnina brings them into the same line of descent with the Lacosomidæ and greatly lessens the apparent contradiction, though it does not entirely remove it.

* V. L. Kellogg, Kansas Univ. Quarterly, III. 45-89 (1894).

† See his paper on Pupæ, loc. cit., pp. 97-119.

The generalized condition of tubercles in the first larval stage of the higher families is like the mature condition in the lower ones, except that throughout tubercle vi. is lacking on the abdominal segments. It thus appears that this tubercle is a secondary one, which I had not suspected from the study of the mature larva alone. The primitive arrangement of the five primary setæ is represented in the accompanying cut (Fig. 3).

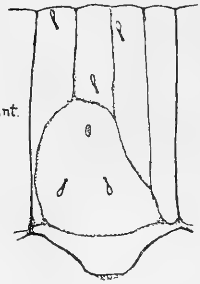

FIG. 3. SEGMENT OF *Nisoniades icelus* IN FIRST LARVAL STAGE SHOWING THE PRIMITIVE ARRANGEMENT OF SETÆ.

Curiously, the most generalized condition is exhibited in the first stage of the Butterflies (Rhopalocera). This is to be accounted for by the fact which was brought out by a comparison of the first stage of such genera as *Danais* and *Grapta* with their later stages, namely, that the armature of the Butterfly larva is not developed mainly from the primary tubercles, but almost entirely independently of them.* Thus their tubercles have remained in the primitive condition, and generally wholly disappear at the first molt.

The primitive arrangement of the setæ is subject to certain displacements which are of a rank greater than that of the family. I have alluded, in my previous paper on this subject, to the separation into Generalized and Specialized Frenatæ. This can not now be retained; but from a consideration of the first larval stage in conjunction with the later stages, I believe that a series of superfamilies † can be satisfactorily defined. This is as far as the classification from the *arrangement* of the

*This is shown beautifully in Dr. W. Müller's plates (Pl. xii. Figs. 2 and 4) in his article on the larvæ of South American Nymphalidæ (Zoologische Jahrbücher 1886, pp. 417–678), and he clearly states the fact on page 673: "Wärzchen secundärer Borsten (Dornen der *Nymphalinæ*)." This valuable confirmation of my views was not met with till after the present article was completed.

†Or tribes in the sense in which this term is employed in Claus & Sedgwick's "Elementary text book of Zoölogy."

tubercles can be carried. The characters on which I would base the superfamilies are as follows:

Order Lepidoptera, suborder Frenatæ.
Tubercles iv and v of larva approximate or consolidated (all stages).*
  Tubercles i and ii remote, normal.................. Cossina.
  Tubercles i and ii approximate or consolidated....... Anthrocerina.
  Tubercle i consolidated with its fellow in dorsal line on abdominal segments 8 or 9 or both........... Saturnina.
Tubercles iv and v remote.
  Tubercles iv (posterior) higher up than v............ Noctuina.
  Tubercle v (anterior) higher up than iv; setæ aborted.. Sphingina.
  Tubercles iv and v usually in line; or iv higher up than v and then armature not derived from primitive tubercles.................................. Rhopalocera.

In the first three superfamilies there is a tendency for the tubercles to become arranged in a single transverse line. This process is begun in the Cossina by the consolidation of tubercles iv. and v. It is completed in the Anthrocerina, as indicated above, by the consolidation of i. and ii. In the Saturnina, the same thing is accomplished in a different way by the disappearance of ii. after the first moult. In the Noctuina and Sphingina the tendency has been toward an arrangement of the tubercles in two alternating rows. To effect this, iv. and v. have become separated and moved out of line. In the Noctuina iv. has been moved upward, but in the Sphingina iv. remained in position and v. was moved, forming the alternation on the other side of the spiracle.

In the Rhopalocera there is little tendency to an alteration of the primitive position, except in a section of the Nymphalidæ, though the development of secondary setæ is often pushed back partially into the first stage, thus complicating the arrangement.

Superfamily Cossina (Microlepidoptera).

Tubercles with single seta, normal, iv. and v. approximate or consolidated, the rest remote. Includes the families Adelidæ, Psychidæ, Cossidæ, Pyralidæ (=Pyralidina), Tortricidæ (= Totricina), Sesiidæ, Tineidæ (=Tineina) Orneodidæ and Lacosomidæ. Probably all the species recorded under these several families belong here except, perhaps, in the case of some of the Tineidæ, with which I am not sufficiently familiar. The Psychidæ differ markedly from the other families in the reversed alternation of tubercles i. and ii., as I have previously pointed out. But I find the family can not be given superfamily rank on this character. The Lacosomidæ belong here by the ar-

* Except in some Tineidæ, as I will show in another article.

rangement of the tubercles as well as of the crotchets on the prolegs. They cannot properly be classed with the Saturnina on larval characters, though the difference is not fundamental. The arrangement of crochets may have been preserved by adaptation, as the larvæ are case-bearers. In the Saturnina the unpaired dorsal tubercle is not an invariable character. In one section it is absent on the 9th abdominal segment, and in one genus (*Anisota*) on the 8th, so that it is not difficult to imagine the Lacosomidæ to represent the most generalized condition of the Saturnina, in which the consolidation of tubercle i. has not taken place on either segment.

In this superfamily, the first larval stage adds nothing to the characters of the tubercles of the mature larva, except as showing the secondary nature of tubercle vi.

Superfamily ANTHROCERINA.

Tubercles with single seta, or converted into warts or absent; i. and ii., as well as iv. and v., approximate or consolidated. Formerly I regarded tubercle i. as absent, but, on further examination, I am able to correct this statement. Includes the families Pterophoridæ, Anthroceridæ (=Zygænidæ, of Hampson), Pyromorhidæ, Megalopygidæ and Eucleidæ.

SYNOPSIS OF FAMILIES.

Body cylindrical, feet normal, setæ single or converted into warts	*PTEROPHORIDÆ.
Body more or less flattened ventrally.	
Tubercles converted into warts; iv+v distinct.	
Legs normal; warts reduced	ANTHROCERIDÆ. PYROMORPHIDÆ.
Two additional pair of prolegs without hooks;† warts hairy	MEGALOPYGIDÆ.
Tubercles converted into spinous processes or absent; iv+v aborted; abdominal feet replaced by sticky ventral surface	EUCLEIDÆ.

Superfamily SATURNINA (Bombycina).

In a section of this group the primitive first larval stage is wanting, the larvæ hatching in an advanced degree of specialization. In the more generalized forms, tubercles with single seta, the base usually prolonged into a stiff (often branched)

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* I have recently discovered that the structure of these larvæ is not so uniform as I had supposed, but I will reserve their discussion for another article.

† Described by Sepp in 1830: by Dukinfield Jones in 1878 (Proc. Lit. and Phil. Soc. of Liverpool, xxxii, pp. 102-104); by Berg in 1882 (Ann. Soc. Cient. Argentina, XIII, p. 269), and more recently by Packard, Lintner, Comstock and Chapman.

chitinous rod (see Fig. 4, A), absent in the case of tubercles ii, and but a single rod bears iv and v. Dorsally on the 8th abdominal segment, the two tubercles i are usually consolidated* and sometimes also on 9th segment. Or the tubercles may be enlarged and bear a crown of hairs or become developed into a bunch of spines. In cludes the families Citheroniidæ, Hemileucidæ, Saturniidæ and Bombycidæ.

I cannot endorse the separation of the Hemileucidæ and Saturniidæ on the characters used by Prof. Smith. According to his arrangement, in the Saturniidæ the antennæ are doubly bipectinate in the ♂, in the Hemileucidæ singly. Now the several genera present a most interesting gradation in this respect, the females being generally behind the males in degree of specialization. Clearly it is an arbitrary division to draw the line between these families on characters exhibited by the male sex alone without further evidence that this separation really corresponds to a dichotomous division in the line of descent. If the female sex had been chosen instead, the division would have corresponded to those defined below in the synopsis. The families could be thus described:

Family *Hemileucidæ.* Antennae of ♀ moth singly bipectinated, of ♂ either singly or doubly so. Larvæ with primitive first stage, a dorsal tubercle on 9th abdominal segment and none on the anal plate. Tubercle shafts densely covered with sharp defensive spines.

Family *Saturniidæ.* Antennæ of both sexes doubly bipectinated. Larvæ lacking the primitive first stage; no dorsal tubercle on 9th abdominal segment, but a pair on the anal plate. Tubercle shafts short or smooth with few weak spines or hairs.

This is essentially the arrangement in Mr. A. R. Grote's check list of 1882 and seems superior to any that has followed it.

In the European *Aglia tau*, the larva possesses all the characters of the Saturniidæ, but differs in the great inequality in development of the tubercles. Their final disappearance in the last stage is less distinctive (compare the American *Samia ceanothi*). In the imago the male antennæ are doubly bipectinated; the female antennæ are serrate (singly). This combination of characters probably entitles the genus to family rank. Dr. Packard (N. Y. Ent. Soc. 1, 7, 1893) places it as a subfamily of the Ceratocampidæ (= Citheroniidæ); but this is negatived by the arrangement of the larval tubercles (though favored by their unequal development) and by the structure of the antennæ of the moth.

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*Except in Anisota. I find that i and ii are both present, i unconsolidated. I formerly erroneously supposed i to be absent (Ann. N. Y. Acad. Sci., viii., 232).

Synopsis of Families.

A single dorsal tubercle on 9th abdominal segment.
  A pair of tubercles on anal plate, ... CITHERONIIDÆ.
  No tubercles on anal plate .... HEMILEUCIDÆ.
No single tubercle on 9th segment.
  Tubercles prominent, ... SATURNIIDÆ.
  Tubercles very unequally developed, later aborted .... AGLIIDÆ.
  Tubercles greatly reduced, ... BOMBYCIDÆ.

Superfamily NOCTUINA.

Tubercles all free, iv. remote, moved up behind the spiracle, except in the Thyatiridæ, where this tendency is counteracted by the development of a secondary tubercle behind iii.; setæ single or transformed into warts. Includes the families Notodontidæ, Thyatiridæ, Dioptidæ, Geometridæ, Brephidæ, Drepanidæ, Agaristidæ, Noctuidæ, Cymbidæ (=Nycteolinæ of Hampson), Lithosiidæ, Pericopidæ, Arctiidæ, Euchromiidæ (=Syntomidæ of Hampson, Zygænidæ Kirby), Lymantriidæ, Eupterotidæ and Lasiocampidæ.*

In a small section of this group the primitive first larval stage is wanting. As several of the families intergrade, not representing dichotomous divisions in the line of descent, the families of the larvæ do not corroborate those of the moths completely. The following synopsis will give some idea of how the characters run, though it is not exhaustive. Further study may develop a better arrangement. The matter is not simple, as the species are numerous.

Tubercles simple, single haired.
  Feet normal.
    Tubercles normal, ... { NOCTUIDÆ (in part). AGARISTIDÆ. NOTODONTIDÆ (in part). CYMBIDÆ. }
    A secondary seta adjacent to iii.; iv. and v. often nearly in line, ... { THYATIRIDÆ. DIOPTIDÆ.† }
  Feet abnormal.
    Last pair of feet modified or aborted; anal plate normal, ... NOTODONTIDÆ.
    Last pair of feet absent; anal plate prolonged, ... DREPANIDÆ.
    Abdominal feet absent except on 6th and 9th segments, ... GEOMETRIDÆ.

* I have not seen larvæ of the Thyridæ, which probably belong to this superfamily

† Mr. T. G. O. Mueller has kindly sent me larvae of *Phryganidia Californica* from San Francisco.

Abdominal feet partly aborted except on 6th and 9th segments	BREPHIDÆ.
Abdominal feet aborted or partly so on segments 3 and 4, ...	NOCTUIDÆ (in part).
Tubercles with hair more or less increased, but not forming true warts, greatly obscured by the development of abundant secondary hairs, ...	NOTODOTIDÆ (in part.) LASIOCAMPIDÆ.
Tubercles converted into warts. On the meso- and meta-thoracic segments above the stigmatal warts—	
Two warts present, ...	NOCTUIDÆ (Bombycoidæ). LITHOSIIDÆ. ARCTIIDÆ. PERICOPIDÆ.(?)
One large wart only present, ...	EUCHROMIIDÆ.
Three warts present, ...	LYMANTRIIDÆ. EUPTEROTIDÆ.

The differences in the arrangement of warts on the thoracic segments in the last section result from the considerable number of primitive setæ on them (see Fig. 2), so that there is not room for each to produce a wart. The consequent doubling up has proceeded on two lines. In the first i a and i b form a single wart, ii a and ii b the second, iv and v the third (stigmatal wart), iii remaining rudimentary or disappearing and vi forming the fourth wart. This is the form exhibited by the Arctians and higher Noctuids. In the Euchromiidæ the two upper warts are consolidated. In the second line (Lymantriidæ), i a apparently forms the first wart, sometimes rudimentary, i b and ii a the second, and ii b the third; the fourth (stigmatal) wart is probably formed much as is the corresponding one in the Arctian type. In a few genera of the Arctiidæ and in the Euchromiidæ tubercle vi is present in the first larval stage, though warts do not appear till the second stage. In the Lymantriidæ the primitive first stage is wholly wanting, the larvæ hatching with well developed warts. I am unable to place the genus *Nola*, as I have not seen stage I. of any species. I must provisionally exclude the genus from the superfamily Noctuina, as the arrangement of warts does not correspond. The structure of the legs is paralleled in the deltoid noctuid genus *Hypena*.

In this connection I would like to discuss briefly Mr. A. G. Butler's paper on "The natural affinit es of the Lepidoptera referred to the genus *Acronycta*,"* published some fifteen years ago. I have not seen any refutation of Mr. Butler's arguments,

*Trans. Ent. Soc. London, 1879, pp. 313-317.

though no one seems to have adopted his conclusions.* Mr. Butler argues that the species of *Acronycta* should be distributed among the Arctiidæ, Lymantriidæ, Notodontidæ and Noctuidæ on account of larval resemblances. That is, though the moths are usually considered congeneric, the larvæ belong to several different families. This would mean, as the classification stood then, two superfamilies in the sense in which that term is used here. It is true the larvæ of the genus Acronycta are wonderfully varied in appearance, but I believe that this diversity is due to mimicry of all sorts of objects from that of resemblage to the foliage (*grisea*, *tritona*, etc.) to warning colors (*oblinita*), and mimicry of special objects, such as a spider's nest (*vulpina*), or of some other specially defended larva (*radcliffei* mimics *Datana* or *luteicoma*, which probably mimics *Notolophus* (*Orgyia*)). The type of larval structure is as usual in the higher Noctuids (Bombycoidæ), but there is also a considerable tendency to the development of secondary hairs (*morula*, *dactylina*, etc.). In one group there is a degeneration to the type of tubercle with single seta (*hamamelis*†), but true warts are present in the early stages.

It will be seen that all the Acronyctæ are excluded from the Lymantriidæ by the arrangement of the warts on the thorax; from the Notodontidæ by the presence of true warts, though sometimes degenerate; from the Arctiidæ they are not distinguished. But these families, Arctiidæ and Noctuidæ integrade even in the venation of the moths. The character which has been used to distinguish them (degree of coalescence of vein 8 with subcostal on hind wings) is an unsatisfactory and inconstant one, and we need not feel surprise that it does not correspond entirely with the development of warts in the larvæ.‡

Thus Mr. Butler's position appears to have been ill-founded. The structure and pattern of coloration of the moths are, in this instance, a better guide to their affinities than the resemblances of the larvæ—that is to say, the superficial resemblances. The structural characters of the larvæ confirm the usual classification, as I have just shown.

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* See, however, a note by Prof. R. Meldola in Weismann's "Studies in the Theory of Descent," p. 169.

† This species is a beautiful instance of the outogenetic stages repeating the course of phylogeny.

‡ Several minor points show that the Acronyctæ belong with the Noctuids. For example, (1) no Arctian has secondary hairs, whereas these occur in the related Noctuid genera (*e. g.*, *Panthea furcilla*); (2) Abdominal segment 8 is characteristically enlarged in most Acronyctæ, and often bears tubercles i and ii in a square. These characters are common to many Noctuids, but are not found among the Arctians.

Superfamily SPHINGINA.

Tubercles all remote, v. moved up in front of the spiracle.* All the primary setæ disappear or become obscured at the first moult. Tubercles i. on 8th abdominal segment are borne on the apex of a long process ("caudal horn"), but they are entirely

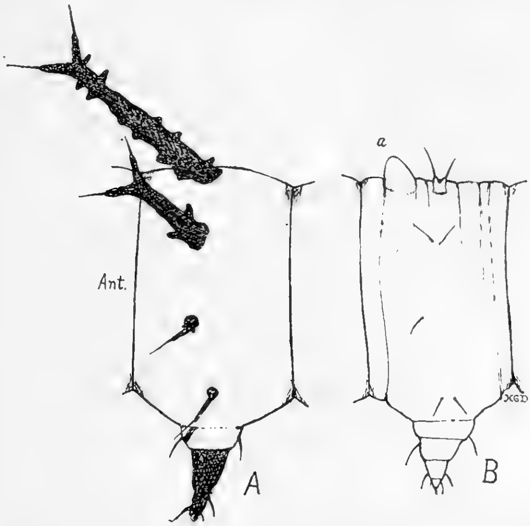

FIG. 4. LEFT SIDE, THORACIC SEGMENTS, STAGE I OF A *Eacles imperialis* and B *Ceratomia amyntor.*

unconsolidated. Includes the family Sphingidæ. The consideration of the first larval stage shows plainly that the Sphingidæ are not related to the Saturnina, but rank as a separate division.† Prof. E. B. Poulton's supposition‡ that the thoracic

* Dr. W. Müller's figure (zoöl. Jahrbücher, 1886, p. 672) of Dilophonota in stage I shows tubercle iv higher up than v. I have not examined the genus and consequently cannot prove what I suspect, namely, that the figure is not quite accurate, as this point was, doubtless, not especially noted. Dr. Müller homologizes the horn of the Sphingidae with the dorsal tubercle of the Saturniidae, as Prof. Poulton has done. He says: "So erscheint es berechtigt, für das Schwanzhorn der *Sphingidæ* die gleiche Genese anzunehmen wie für den unpaaren Dorn der *Saturniadæ* auf 11. [abdominal segment 8] Beide sind entstanden aus den Stützgebilden der beiden Borsten i auf Segment 11." The analogy is certainly close, but I was led to suspect that the structures were not homologous before the condition of tubercles iv and v proved to me that they were not. Dr. Müller seems not to appreciate the nature of tubercle vi. This is not surprising, as he has worked almost entirely with the most highly specialized family of Lepidoptera. In Dilophonota he has mistaken vii for vi.

† I fell into a sad muddle concerning this family before I appreciated the secondary nature of tubercle vi. See Ann. N. Y. Acad. Sci., viii, 232, note.

‡ Trans. Ent. Soc.. Lond., 1888, p. 571.

horns of *Ceratomia amyntor* might be homologous with those of the Citheroniidæ, I can show to be unfounded, for in the first larval stage of this Sphinx these processes arise anterior to the setæ and entirely independently of them, whereas in the Citheroniidæ the horns are developed out of the corresponding tubercles. (See Fig. 4. Tubercles iii and v are absent (as usual in stage I.) and in Ceratomia vi is represented by two setæ. At a is shown the rudiment of the future thoracic horn of Ceratomia.)

Superfamily RHOPALOCERA.

Tubercles and setæ primitive, often rudimentary and disappearing at first moult. Tubercles iv and v usually in line, rarely iv moved up a little or considerably out of line (Danainæ, Nymphalinæ). Armature processes of mature larva, when present, derived independently of the tubercles, but often occupying approximately the same position. Includes the families Papilionidæ, Pieridæ, Hesperidæ, Lycænidæ and Nymphalidæ.

The setæ are either single or multiple in the first stage. The multiplication is very slight in some cases, so that it is difficult to say at what point the primitive first stage has disappeared. It is definitely lacking in most of the Papilionidæ, though this family is otherwise among the most generalized. The processes of the Nymphalidæ do not appear till after the first moult or later. and the unpaired dorsal series of this family is independently derived and does not correspond to the unpaired tubercles of the Saturnina.*

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*The figure of *Melitæa phaeton*. stage I, by Dr. A. Gruber (Jena Zeits. für Naturwissenschaft, Vol. XVIII: see reprint in Papilio, Vol. IV, pl. iii, Fig. 25) appears to contradict my generalization. It represents a single dorsal seta with no sign of consolidation. I have not seen Melitæa, but Mr. S. H. Scudder ("Butterflies of the Eastern U. S. and Canada, Vol. I, pp. 619 and 688) gives careful descriptions of it. He says, "Papillæ . . . all arranged in paired rows," and further describes the arrangement in detail. It is quite normal, except that iv. seems to be moved up a little.

Mr. Scudder devotes four plates to figures of newly hatched larvæ. In most of these figures the setæ are very plainly shown, and iv. and v. are approximately in line. Plate 70, Fig. 3, well illustrates the peculiar arrangement of *Danais archippus*, showing the additional subdorsal seta above i. *Vanessa antiopa* (pl. 70, Fig. 12) shows tubercle iv. moved up behind the spiracle, very much as in the Noctuina, and *Grapta faunus* (Fig. 8) is similar, apparently with the addition of tubercle vi., bearing two setæ. It thus appears that in certain genera of the Nymphalidæ (the most specialized family) the primitive arrangement of the setæ is displaced, perhaps owing to a tendency to the disappearance of the primitive first stage. In *Grapta progne*, which I have examined, iv. is only moved up a very little out of line with v., but v. bears two setæ. Mr. Scudder's figures of the Lycænidæ (pl. 71) show a number of supplementary setæ, the most generalized condition being shown in Fig. 2 (*Thecla liparops*), where the arrangement seems normal. The figure of *Pieris rapæ* (pl. 72, Fig. 8) is poor. The arrangement of the setæ is really normal, iv. and v. being in line. In *Anthrocharis genutia* (pl. 73, Fig. 9) tubercle v. seems to be wanting.

In the Papilionidæ, more than in any of the other families, the warts are derived from the primitive tubercles. The correspondence with the moths is close, but the single wart below the spiracles, though corresponding to iv. and v., does not seem to be

Unrecognized Families.

The following families, occurring in North America, have been temporarily omitted, as I have not yet seen sufficient material to place them. Thyridæ and genus *Nola* of the Lithosiidæ.

COMPARISON WITH RECENT CLASSIFICATIONS.

I have already shown that my classification of the larvæ does not corroborate Prof. Comstock's minor divisions of the Frenatæ. By taking his characters in different order, I was able approximately to define the "Generalized" and "Specialized Frenatæ;" but with the correction of my account of the tubercles of the Saturnina, these divisions do not correspond to my primary division of the larvæ. The generalized Frenatæ comprise only the Cossina and Anthrocerina, with the exception of the Lacosomidæ.

Recently Mr. G. F. Hampson reviews Prof. Comstock's work,* and proposes a somewhat different classification of the Frenatæ. The characters he uses are as follows :

Fore wing with vein 1 c present, ... § 1.
Fore wing with vein 1 c absent.
  Fore wing with vein 5 from the middle of the cross vein, the venules arising at regular distances, ... § 2.
  Fore wing with vein 5 arising nearer 4 than 6.
    Hind wing with vein 8 nearly or quite touching 7 or connected with subcostal by a bar, ... § 3.
    Hind wing with vein 8 remote from 7 beyond origin, ... § 4.
  Fore wing with vein 5 from middle of cross vein or nearer 6 than 4, the veins not arising at regular distances around the cell, ... § 5.

The first two sections correspond to my Cossina and Anthrocerina, but with the families mixed, except the Pyralidæ, which which are in section 3. Sections 3 and 4 correspond to my Noctuina in part with the Pyralidæ included. Section 5 takes

derived from a consolidation of these tubercles. I place the Papilionidæ lowest in the following

Synopsis of Families.

Tubercles converted into papillose warts, at least in part; primitive first stage wanting...... .. .. Papilionidæ.
Setæ single or multiple, no true warts.
  Setæ simple or normal, reduced and supplemented by secondary hairs in later stages, head proportionate .... Pieridæ.
  Setæ simple; head disproportionately large, prothoracic segment small.. Hesperidæ.
  Setæ confused and supplemented by secondary hairs in the first stage; body flattened; head retractile.................................. Lycænidæ.
  Setæ primitive and rudimentary or normal or reduplicated, occasionally displaced, iv being moved up out of line with v, in which case the mature armor is secondary.............................. Nymphalidæ.

* Annals and Magazine of Nat. Hist. (6), XIV. pp. 254-261 (1894).

in the rest of the Noctuina, the Sphingina, Rhopalocera and Saturnina. Evidently there is no more than a general correspondence here, and the Saturnina are again the worst stumbling block. It is possible that the consolidation of tubercles iv and v in the Saturnina has occurred independently of the same process in the two lowest superfamilies; and this would seem to be indicated by the entirely different method employed in getting rid of tubercle ii. But, if this is so, we have again to contend with the contradiction furnished by the Lacosomidæ, and to suppose that the process of modification of these moths has been likewise entirely independent, while so closely parallel to the Saturnina. This supposition I was obliged to make in my former paper.

I am inclined to the opinion that the veins of the wings alone are not adequate to give a natural classification of the Lepidoptera.* That is, certain lines of specialization give the same ultimate structure, though acting on phylogenetically dissimilar groups, and that the true relationships may be thus obscured.

As far as I have gone the arrangement of the tubercles of the larvæ gives remarkably absolute characters (except when the primitive first stage is lost). This is not the case with the presence of vein 1 c, the primary division according to venation. Vein 1 c is a more or less gradually evanescent character, generally tending to disappear as soon as specialization sets in.† The position of vein 5 is probably constant after it has once taken up a positive direction of migration; but it seems probable that it has remained neutral till late in the history of several groups and subsequently produced several parallel lines of modification. This seems to me to be the explanation of the strange mixture of families found in Mr. Hampson's last section.

Prof. S. F. Clark, "On the breeding habits of the Alligator," noting occurrence of nests, character of eggs, and collecting methods.

Prof. H. F. Osborn exhibited and described the skull structure of *Titanotheres* (specimens recently collected by Dr. Wortman and Mr. Plummer), and commented on the mode of evolu-

* Prof. Smith remarks: "....... I do not believe that the present basis for our classification is a correct one ....the entire external skeleton of the Lepidoptera has received practically no consideration......." (Entom. News., V. 240; 1894).

† I think the Pyralidæ illustrate the superiority of the larval tubercles as characters of classification. Mr. Hampson places the Pyralids in the Macrolepidoptera because vein 1 c has disappeared on the fore wings, though it is still present on the hind wings. Dr. Chapman would have to place them part in the Macros, part in the Micros, because the crotchets on the larval prolegs form a complete circle in most, but only a part circle in others. From the larval tubercles, the Pyralids are all true Micros.

tion of horns. There was also exhibited the skull of the great creodont, *Mesonyx uintensis.*

Bashford Dean exhibited and commented on specimens of *Palæospondylus.* He also exhibited mummied fishes of the genus *Latis*, from Thebes, which by comparison with a recent species were found to have undergone no perceptible variation.

Meeting adjourned.

BASHFORD DEAN,
Recording Secretary of Section.

STATED MEETING.

November 19th, 1894.

The Academy organized with Vice-President Whitfield in the chair. Eleven persons present.

The nominations for resident membership of Prof. Charles L. Bristol and Prof. M. Allen Starr were referred to the Council.

The Section of Geology and Mineralogy then organized, Prof. Whitfield in the chair.

Prof. D. S. Martin presented a report of the Committee on Standard Sizes of Trays, etc., and, on motion, he was requested to present it at the next regular business meeting of the Academy.

The first paper of the evening was read by Prof. R. P. Whitfield: (*a*) "On a New Seaweed from the Trenton Rocks of Wisconsin;" (*b*) "On Embryonic *Baculites* from the Black Hills." Paper (*a*) appears in the Bull. Amer. Mus. Nat. Hist. VI., 351, December, 1894.

The second paper was by Dr. E. O. Hovey, "On the Origin and Microscopic Structure of the Cherts of Missouri." Discussion followed by Prof. Kemp and Dr. Levison. The paper appears in the Amer. Jour. Sci., November, 1894, p. 491.

The third paper by Prof. C. H. Smyth, of Hamilton College, was read by the Secretary in the absence of the author, "On the so-called serpentine associated with the red hematites at Antwerp, N. Y." In a different form this paper will be found in the Journal of Geology II., 667.

The last paper of the evening was read by J. F. Kemp, "The Geological Section exhibited by the new tunnel under the East River, at 70th Street." The paper is printed later on in this volume.

Mr. G. F. Kunz exhibited to the Academy reproductions of rock sections in polarized light from photographs taken through color screens by Kurtz, of New York. By cutting off the complementary colors of red, green, and blue, and then printing from the negatives with inks of these colors, remarkably accurate reproductions are attained.

The Academy then adjourned.

J. F. KEMP,
Recording Secretary of Section and Academy.

STATED MEETING.

November 26th, 1894.

The Academy met and listened to the second public lecture of the course for 1894–95, by Prof. R. S. Woodward, entitled "An Historical Sketch of the Development of the Science of Mechanics." (Printed in "Science," Feb. 8, 1895.)

J. F. KEMP,
Recording Secretary.

REGULAR BUSINESS MEETING.

December 3d, 1894.

The Academy was called to order by President REES, about thirty persons being present.

The Secretary read the minutes of the last business meeting, and on motion they were approved.

The Secretary presented from the Council the following nominations:

Prof. CHARLES L. BRISTOL, Resident Member.

Prof. M. ALLEN STARR, Resident Member.

On motion they were elected. The Secretary announced the appointment by the Council of the following committee to have in charge the annual reception: Prof. Wm. Hallock, chairman; Messrs. C. F. Cox, F. S. Lee, Bashford Dean and Frank M. Chapman.

Mr. Chapman subsequently resigned and was replaced by Dr. J. L. Wortman.

Prof. D. S. Martin presented the postponed report of the committee on Standard Sizes, etc., and on motion it was referred to the Biological and Geological Sections.

The Section of Astronomy and Physics then organized, President Rees continuing in the chair.

The first paper was by F. B. Crocker, "On the Causes of Fly Wheel Accidents in Electric Stations." Prof. Crocker outlined the methods for calculating fly-wheel sizes and stresses, and gave the result of some experiments with lead wheels, which clearly showed bulging where the greatest stress existed. He also tried a lead wheel on an electric motor, to show the method of observation. The paper was discussed by a number of those present.

The second paper was by H. C. Parker, "On the present Range and Accuracy in the Measurement of Electrical Resistance." Mr. Parker outlined the methods of measuring high and low resistances, and showed that the range was from one ten millionth of an ohm to ten million million ohms, or from 10^{-7} to 10^{13} ohms, a range of 10^{20}. He also gave several illustrations of the meaning of this range. The paper was generally discussed.

On motion the meeting adjourned.

WM. HALLOCK,
Secretary of Section.

J. F. KEMP,
Recording Secretary.

Stated Meeting.

December 10th, 1894.

An attendance of twenty-eight. Prof. H. F. Osborn in the chair in the absence of Prof. Britton. The minutes of the previous meeting and of those of the general meeting of the Biological Section were read and approved.

The report of Prof. D. S. Martin, representing a committee of the Academy appointed to consider the matter of standard sizes of trays and boxes for mineralogical specimens, etc., was presented, approving the character of trays exhibited by Mr. Levison, and requesting that action be taken regarding the work of the committee. After considerable discussion the report was referred to Geological Section of the Academy.

The following were nominated for resident-membership: Prof. William Stratford and Mr. Isaac M. Dyckman, and the names were referred to the Council.

The Biological Section organizing, a paper was read by Dr. J. G. Curtis "On the unpublished portion of Galen's Treatise upon Practical Anatomy and Experimental Physiology." The writer had, by the courtesy of the authorities of the Bodleian Library, secured photographs of an Arabic manuscript which contained the latter books (partly and imperfectly translated, and as yet unpublished) of the treatise on technical anatomy. The careful translation will, it seems justly probable, give a more exact knowledge of the anatomical learning of the ancients.

The following three papers, owing to the lateness of the hour, were deferred to a subsequent meeting.

F. M. Chapman, "Remarks on the Habits of certain Tropical Birds."

J. L Wortman, "On the so-called Devil's Corkscrew, *Daimonhelix*, of Nebraska."

Arnold Graf, "On the Excretory System and on the Origin of Pigment in *Nephelis* and *Clepsine*."

Meeting adjourned.

BASHFORD DEAN,
Recording Secretary of Biological Section.

STATED MEETING.

December 17th, 1894.

The Section of Geology and Mineralogy at once organized. Twelve persons present.

In the absence of the chairman, Dr. L. H. Laudy was called to the chair. The minutes of the last meeting of the Section were read and approved.

Prof. D. S. Martin presented a report from the Committee on Standard Sizes, and on motion the report was accepted and referred to the Committee on Publication, and the committee was discharged.

The first paper of the evening was by J. A. Matthews, entitled "Notes on Carborundum." The paper was illustrated by many specimens, and was discussed by Messrs. Laudy, Levison, Luquer, Martin and Kemp. It will appear in the School of Mines Quarterly of current date.

The second paper was by Dr. Bashford Dean, "On the Mounds and Mound-builders of Ohio," and was discussed by Dr. Martin.

The third paper was by Mr. L. McI. Luquer, "On the relative Effects of Frost and Sulphate of Soda Efflorescence as shown by tests of Building Stones." The paper will appear in the School of Mines Quarterly.

After discussion by several members the Academy adjourned.

J. F. KEMP,
Recording Secretary.

Regular Business Meeting.

January 7th, 1895.

The Academy was called to order by Pres. Rees. The attendance was twenty.

The minutes of the last meeting were read and approved. The Secretary presented from the Council the following names:

Prof. William Stratford, Resident Member, Mr. Isaac M. Dyckman, recommended for election, and on motion they were elected.

The Section of Astronomy and Physics then organized, Prof. Pupin being elected Secretary pro. tem. The minutes of the last Sectional meeting were read and approved.

The first paper was by Herman S. Davis, entitled "The methods employed in deducing definitive declinations and proper motions of fifty-six stars, used in the investigation of the variation of latitude at Columbia College."

After explaining the nature of the latitude investigation and the reason of the choice of this list of 56 stars, he outlined the preliminary work done towards their reduction by Professor Jacoby, Dr. Humason and himself during the fall of 1894, and how, when Professor Jacoby was taken ill, the entire work was officially placed by Professor Rees, in December, 1894, in his hands for completion. Having given a brief resumé of similar work in star reduction by Argelander, Auwers, Safford and Boss, he explained that the desire to include, so far as attainable, all observations made since 1750, and to profit by the experience and labors of these four predecessors, together with the application of the most recent determinations of systematic corrections, etc., had been the controlling motive of the work. While some very poor catalogues have been corrected and a corresponding weight given to their positions, a few other catalogues, usually of like low weight, have not been consulted, on account of the impossibility of finding copies of them, but this is thought to be exceptional, and, so far as at present known, every catalogue of worth, as well as observations forwarded by various astronomers in manuscript have been utilized. A total of 13,762 observations have been found, of which 543 were given zero weight, leaving an available average of 236 per star. These were taken from 134 separate catalogues or lists and 157 additional annual volumes, original records, etc., the average number of catalogues in which each star was found being 25. Since a determination of proper motion was in view, it was necessary to know the mean data of observation of the declination for any given catalogue, in order that a correction might be applied for the erroneous proper motion assumed by the observer in the reduction of the position at the time of observation to the epoch of the catalogue. Modern catalogues give this data, but for the earlier ones, Piazzi, Lalande, Taylor, Pond, Abo, and others, it had to be deduced from the original record of the observations, by a careful search through all the many pages of records to find each particular observation.

A somewhat similar process was followed in the case of the declinations for all the volumes of annual results not yet reduced to a determinate catalogue, the process followed being to find all the observations, then to reduce each one separately to the epoch 1875.0 and finally take the mean of all by weight proportional to the number of observations and regard this as a single determination of declination; thus what will be printed in the final paper as one line was often the work of weeks of research and computation. Again, it was often necessary to reduce in this manner (or otherwise by the aid of such tables as von Asten's for Lalande, or Luther's for Weisse-Bessel), even observations which have been already presented in catalogue form—this being the case on account of the inaccuracy of the catalogue-computers, or of the constants assumed in the reduction. After all catalogues had been reduced to the common epoch 1875.0 and corrected for erroneous proper motion, a further correction was applied to all to make each declination conform to a standard system of reduction (in this case to the Astronomische Gesellsschaft System of Auwers'

Publication XIV.). For most of the best catalogues these systematic corrections were taken from Auwers' paper in Astron. Nach. 3196; for others it was taken from Boss' paper on Declinations of Fixed Stars, and corrected by a quantity (the result of special research), which would convert Boss' corrections from the Boss-system to the A. G. C. system. For several other catalogues not included in either of these lists a systematic correction was independently deduced from the observations themselves in a manner similar to that pursued by Auwers. With the data thus found the declination and the proper motion were deduced by the method of least squares, and from the residuals then found by substitution in the equations of condition probable errors of both declination and proper motion were computed by the usual formulæ. The average probable error of the declination reduced to 1875 for the fifty six stars is thus found to be 0.″095 with an average weight of 34, determined by an average of 236 observations; and for proper motion likewise the average probable error is 0.″0035 with an average weight of 17,020.

These results appear to compare very favorably with work of the same kind done elsewhere, and give the position of these stars such a precision as will make the absolute latitude-formula for Columbia College Observatory very accurate, and as will also give astronomers here and elsewhere fifty-six more fundamental points of reference in the northern heavens.

The second paper was by Prof. A. M. Mayer, "On Chladni's figures formed on vibrating plates strewn with sand;" with experiments showing the method of obtaining these figures; and the exhibition of the figures in sand transferred to paper by a process invented by Prof. Mayer; also the comparison of the real figures with those given by the Physico-Mathematical investigations of Lord Rayleigh and with those given in textbooks on Physics.

The paper was not intended for publication, and after discussion the Academy adjourned.

J. F. KEMP,
Recording Secretary.

Regular Meeting.

January 14th, 1895.

The Biological Section immediately organized in the absence of regular business, Professor Britton presiding. An attendance of fifty. The minutes of the previous meeting of the Section were read and approved.

A paper was read by Mr. R. H. Cunningham, "On the sources of Illumination for Photo-micrography, with special reference to the Arc light." Discussion followed in which Drs. Piffard and Laudy took part.

Mr. C. F. Cox in a following paper discussed some of the latest theories of diatom structure, exhibiting a series of slides of photomicrographs, mainly of broken frustules, which he had received from Mr. T. F. Smith while in London.

Mr. O. S. Strong spoke briefly on his recent modification of the Golgi method in nerve-histology, and exhibited a number of photo-micrographs of his preparations.

These had been taken by Dr. Edward Leaming, who in the first paper of the evening showed a number of photographic slides of his recent work. A series of slides illustrating the fertilization phenomena of the Sea-urchin, *Toxopneustes*, taken from Dr. E B. Wilson's preparations, proved especially noteworthy.

Bashford Dean,
Recording Secretary of Biological Section.

Stated Meeting.

January 21st, 1895.

The Academy was called to order by Vice-President Whitfield, twenty-five persons being present. The minutes of the last meeting were read and approved.

Prof. D. S. Martin called attention to the death, the previous week, of Mr. George N. Lawrence, one of the oldest and most distinguished members of the Academy; and to that of Mr. Robert H. Lamborn, well known as an archæologist. Prof. Martin made a brief memorial address.

In view of the fact that it was most appropriate for the Section of Biology to take suitable action regarding a memorial of Mr. Lawrence, it was moved and carried that the President of the Academy appoint a committee of one to prepare a memorial of Mr. Lamborn. Prof. D. S. Martin was subsequently appointed.

The paper of the evening was then read by Prof. R. S. Woodward, entitled "The Condition of the Interior of the Earth," of which the following is an abstract:

The two envelopes of the earth, the atmosphere and the ocean are important factors in the problem of the interior, and yet we know less of the condition of the outer atmosphere than of the inner earth. The atmosphere's shape we can calculate with some approximation to the truth as an oblate spheroid, whose polar radius is 5.4 times the earth's radius, and whose equatorial radius is 7.6 times the latter. This shape is determined by centrifugal force and gravity. Its bulk is 310 times that of the earth, but its mass is only one-millionth that of the latter. If we speak of the latter as 6642×10^{18} tons we can get some conception of the mass of the atmosphere, and of its extreme tenuity in the outer portions.

Our inferences regarding the interior of the earth rest chiefly upon four facts, viz.

1. Its shape and size, which are known with great accuracy.

2. Its surface density, 2.6.

3. Its mean density, 5.58, which is probably accurate within two units in the second decimal place.

4. The precession ratio $\frac{C-A}{C}$, in which C is the moment of inertia of the earth with respect to the polar axis, and A is the moment of inertia with respect to an equatorial axis.

These facts limit the distribution of the earth's mass. The density of the mass must increase from the surface toward the center. Various laws of its increase have been proposed, of which that of Laplace seems to be on the whole the most plausible.

It is important to appreciate that the strata rest upon one another substantially as if fluid, because the arch of the crust is so flat. The compressive stress on any portion considered as a keystone is 30 times the crushing strength of steel, and 500–1000 times that of granite and limestone, whence it follows that the earth is practically in hydrostatic equilibrium. It also follows that the pressures in the interior are excessive, and that at the center the pressure is about 3,000,000 atmospheres. The earth is 'solid,' as the word is used by Lord Kelvin, that is, it has no cavities below a comparatively shallow depth. The explanations of the changes of latitude lately advanced and based on internal hollows in which loose matter rolls around are absurd. There is perfect continuity of matter, and there is only fluidity when for some local cause the pressure is somewhat relieved. As Major Dutton has shown, the transmission of vibrations from the centrum of the Charleston earthquake indicated a medium nearly as homogeneous as steel.

Geologists have had to account for movements of the crust, such as subsidence, elevation, crumpling, folding, etc. Two elementary forces are necessarily appealed to. The first is *Gravity*: the second that due to the *Earth's Internal Heat.* The idea of the earlier geologists that the earth cooled and contracted and hence caused the disturbances has been mostly relied on as an explanation, but for the last ten or fifteen years has been felt to be insufficient. The idea of Babbage and Herschel that loaded areas, or areas of sedimentation sink and crumple up the adjacent areas as mountains, tending thus to renew and perpetuate regions of upheaval, has also had believers. This has had its best formulation in the recent doctrine called *isostasy*, which regards the earth as a body in essentially hydrostatic equilibrium, and as balancing inequalities of pressure by subterranean flow. The speaker regarded this doctrine, however, as insufficient in that it furnishes no start and tends to run rapidly down. We need secular contraction to keep isostasy at work. The earth's internal heat is the great store of energy available for this purpose. How to explain the earth's internal heat is a hard and dark problem. The nebular hypothesis, first outlined in Leibnitz's Protogea, has been most widely believed. The critical stage in this method of development came when convection ceased and the sphere was all the same temperature, the stage usually called *consistentior status*. Then came the formation of a crust and the beginning of geological phenomena as usually discussed. The speaker had reason to question the reliability of the nebular hypothesis and whether the earth had ever been gaseous, etc. An origin for the globe and an explanation of its heat are perhaps as well to be found in the collision of meteoric bodies.

The time that has elapsed since the *consistentior status* has been an interesting subject for computations, and widely varying estimates have been made. Lord Kelvin in 1862, on very questionable data, placed the limits of geological phenomena at 20,000,000–400,000,000 years in the past. On the same line, Tait estimated 10,000,000, but it is doubtless true that in England the weight of Kelvin's authority fettered geological thought in the last thirty years to too narrow limits of time, for no geologist of eminence questioned his results. Yet within a month Lord Kelvin has raised his upper limit to a possible 4,000,000,000. All must appreciate that if the data are unreliable, the finest processes of mathematics will lead to no certain result.

The speaker concluded that to secular cooling must be attributed the principal motive force. The main criticism raised against it is its insufficiency, but George Darwin has shown that as a cause it can be mathematically shown to be able to produce results at least of the same order as those observed. In the speaker's estimation it is probably sufficient, although the heat radiated is a very difficult thing to measure in a reliable way. Our data are all from the continents, and they have not been obtained in sufficient quantity. The oceanic areas are necessarily unobserved.

In discussion Professor Kemp stated that attention had naturally been drawn to the interior of the earth in the endeavor to explain, first of all, the contrasts of the continental elevations and the oceanic abysses, and secondly, the crumplings, foldings and faults of mountainous regions. Herschel's explanation, while rational and simple on the face of it, is inapplicable because it is the areas of sedimentation, subsidence and "overloading" that later on are upheaved in the mountains, and this apparent contradiction is the great difficulty. He also referred to the measures of rigidity of the crust, to the remarkable localization of the yielding along narrow lines when it did come, and to its relatively short duration. He asked Professor Woodward to touch on the slowing up of the revolution of the earth and the consequent readjustment of the spheroid to the lessening of centrifugal force, an idea advanced some years ago by W. B. Taylor.

In reply Professor Woodward admitted that the questions were old and very difficult ones, and that for the mountains he had no explanation to advance. He spoke of the mountain protuberances as measures of rigidity, and yet this must be qualified by the statement that according to isostasy and to recent pendulum observations they appear to be somewhat lighter under the surface. As to the slowing up of rotation and loss of centrifugal force, the idea was an important and valuable one, but it did not appear to be sufficient to account for the results.

Professor Rees referred to the recent observations on changes in latitude made under his direction, and to certain factors that entered into the calculations which would throw light on the question.

Professor Hallock brought up the recent results of experiments on the gyration of liquids as bearing on the question and proving that a fluid set in rapid rotation continues to gyrate long after the enclosing vessel ceases. The curious results obtained at the Waterville arsenal in the great testing machine were also cited. The attempt was made to burst a cast iron cylinder by forcing into it, through a three-sixteenth of an inch hole, paraffine and tallow. But it was found that both these substances became, under high pressures, more rigid than steel and could not be driven through the hole.

Prof. Britton asked Prof. Woodward if the amount of heat radiated per annum could be quantitatively expressed, and in reply Prof. Woodward said it is computed from the meagre data to be enough to melt a layer of ice 5 to 7 mm. thick over the earth's surface. The chairman, Prof. R. P. Whitfield, in closing the discussion called attention to the fact that the submarine crumpling and upheaval were not well known nor often taken into account, and yet they probably far exceed all that we see on the continents.

The Academy then adjourned.

J. F. KEMP,
Recording Secretary.

STATED MEETING.

January 28th, 1895.

The Academy met and listened to the third public lecture of the course for 1894–95 by Prof. E. B. Wilson, entitled "The Newer Problems of Embryology." Sixty persons present.

J. F. KEMP,
Recording Secretary.

REGULAR BUSINESS MEETING.

February 4th, 1895.

The meeting was called to order by President REES, with twenty members and guests present. In the absence of the Secretary, Prof. William Hallock was made Secretary pro. tem. of the Academy. The minutes of the last meeting were read and approved. There being no general business the Section of Astronomy and Physics organized, with President Rees continuing in the chair.

The first paper was upon "A new photographic method of comparing the pitch of tuning forks," illustrated by experiment and lantern slides. The method consists in placing each fork in front of the diaphragm of a manometric capsule and then photographing the flames (see Physical Review, Vol. II., No. 10, Jan.–Feb. 1895). Then counting the waves in each line gives the ratio between the vibrations of the two forks.

The second paper was by J. K. Rees on "The Penumbrae of sun-spots as shown in Rutherfurd's photographs, with special reference to the discussion at the December meeting of the Royal Astronomical Society." Professor Rees called the attention of the Section to the remarks made by the Rev. F. Howlett on presenting to the Royal Astronomical Society of London, three volumes of sun-spot drawings. This set of volumes contains drawings made during a period of thirty-five years, and shows minute details in regard to the forms and changes of solar spots. The Rev. Mr. Howlett stated that his main object in continuing the series had been to test the theory put forth by Professor Wilson, of Glasgow, in the latter part of the last century. Wilson's theory claimed that the penumbra in a spot shelves down toward the umbra; and that the portion of the penumbra nearest the sun's centre will, therefore, grow narrower and narrower, due to perspective, as the sun-spot reaches a a point nearer and nearer to the limb. Mr. Howlett claimed that his drawings showed that the Wilsonian theory was not borne out by his observations as recorded in his drawings. He made bold to say that instead of the penumbra of the spot possessing shelving sides sloping down toward the umbra, the penumbra shows a convex surface in a curve comformable to the general contour of the solar surface. He remarked that he had not himself witnessed a single case of certain notching of the limb. Professor Rees exhibited on the screen a series of fine photographs of the solar surface taken by Mr. Rutherfurd with his photographic telescope (13 inches diameter of object glass, 11 feet of focal length) during the year 1870–71. Attention was called to the appearance of the penumbral regions of the spots, which showed conclusively that the penumbra was as a rule eccentric with respect to the umbra. Spots were pointed out near the centre of the sun where the penumbral marking was deficient, on sometimes the west side, then on the east side, sometimes on the north side and sometimes on the south side. Spots were also indicated which showed, when near the limb of the sun, the penumbral region wanting on the side farthest from the centre and well developed on the side toward the centre. So far as indicated by these photographs, there was no doubt that the Wilson theory did not completely explain the various phenomena.

Professor Rees also showed some pictures of sun-spots taken by Mr. C. A. Post, of New York City, exhibiting the non-central character of the umbra with respect to the penumbra. Mr. C. A. Post, of New York City, then threw on the screen some original photographs of the sun and moon. He also exhibited a series of strikingly beautiful lantern slides made from photographs of lightning flashes by Mr. Bridgham, president of the New York Camera Club.

The third paper was by M. I. Pupin "On a new form of automatic mercury vacuum pump." It consists of a sprengel pump of especial form combined with a very ingenious device for lifting the mercury to the reservoir again by means of an auxiliary pump of low capacity. At the close of the meeting the members and guests visited Professor Pupin's laboratory and saw the pump in operation. The pump that was shown is a slight modification of the one described in the Am. Journ. Sci., 1895, Vol. 49, p. 19.

WM. HALLOCK.
Recording Secretary of Section.

STATED MEETING.

February 11th, 1895.

Biological Section, Professor Britton in the chair.

An attendance of twenty-eight.

Previous to the organization of the Biological Section, the Recording Secretary presented a communication from the Scientific Alliance, requesting that the Academy approve of the steps initiated for the incorporation of the Alliance.

On motion the letter was referred to the Council with power.

Mr. Livingston Farrand was nominated as a regular member, and the nomination was referred to the Council.

The minutes of the previous meeting of the Section were read and approved.

The following papers were presented:

Dr. J. L. Wortman, "On the so-called Devil's Corkscrew, *Daimonhelix*, of Nebraska. Dr. Wortman described its mode of occurrence and probable nature. It is to be regarded as of vegetable origin.

Dr. Arnold Graf, "On the excretory system of the Leeches, Clepsine and Nephelis." The living tissues were examined as transparent objects and the results recorded in the paper were thus obtained.

Albert Schneider, "The Occurrence and Functions of Rhizobia." The paper described experiments which the writer had made to cultivate these nitrogenous growths on the roots of Indian corn.

Prof. N. L. Britton, "An Undescribed *Ranunculus* from the Mountains of Virginia."

Prof. Bristol exhibited a newly modified water-bath, which was made of spun copper, was circular in shape, and possessed convenient adjustments.

Meeting adjourned.

BASHFORD DEAN,
Recording Secretary of Section.

Stated Meeting.

February 18th, 1895.

The Academy met and was called to order by the Secretary. In the absence of the President it was moved and carried that Prof. J. J. Stevenson take the chair. Twenty-four persons were present. The following paper was read by title and referred to the Publication Committee:

H. G. Dyar, "The Bacteria in the Air of New York."

The Section of Geology and Mineralogy at once organized and the minutes of the previous meeting were read and approved. The first paper was the following:

ON A GRANITE-DIORITE NEAR HARRISON, WESTCHESTER COUNTY, N. Y.

By Heinrich Ries.

The greater portion of Westchester county is formed of a series of metamorphic rocks, which, according to Merrill,* comprise the following members:

1. A basal red gneiss, called the Yonkers gneiss.
2. A grey gneiss, called the Fordham gneiss.
3. Quartzite.
4. The Inwood limestone or dolomite.
5. Mica-schists or Manhattan schists.

These rocks extend across the county from north to south, in more or less parallel bands, and show a high dip. In the eastern portion of Westchester county the rock is a mica-schist which becomes highly quartzose along the shore of Long Island Sound.

The only igneous rocks thus far described from Westchester county are the well-known Cortlandt series† of diorites and gabbros near Peekskill, N. Y., which were studied and described in detail by the late Prof. G. H. Williams, and also by Prof. J. D. Dana.‡ In addition Dr. Merrill calls attention to many localities of hornblendic and augitic strata, rarely more than a few feet in thickness, which are probably metamorphosed eruptive

* Amer. Jour. Sci., iii., XXXIX., 383.

†Ibid. iii., XXXV., 438; XXXI., p. 26; XXXIII., p. 135-191.

‡A. J. S., iii., XXII., p. 103.

rocks, and adds that the serpentine of New York City may have had a similar origin.

Several years ago the writer was informed by Dr. Merrill that there were west of Harrison, Westchester county several outcrops of a rock apparently granitic. A subsequent visit to the locality showed that there were not only a few isolated outcrops, but a large area of the rock, extending from a point southwest of Larchmont to about a quarter of a mile north of Port Chester, a distance of seven miles. The average width of the area is one mile. There is an additional smaller area which forms Milton Point, east of Port Chester and Rye. It may be a branch of the main area, but this point could not be determined owing to the scarcity of outcrops. Between the two and on the western edge of the town of Port Chester is an area of serpentine, but the latter is not considered in this paper.

The southern, western and northern boundaries of the main exposure are uncertain on account of the mantle of drift, but the eastern boundary follows approximately the line of the New York, New Haven & Hartford Railroad to Harrison and then strikes north.

Throughout its extent the rock has a pronounced gneissic structure, which varies from a more or less massive gneiss in the central portion of the area to a mica-schist at many points along the border. The former is well seen just northwest of the Larchmont station, and the latter west of Mamaroneck, Port Chester and at the tip of Milton Point. The strike is N. 40–60° W., and the dip 70° S. W.

Just west of Mamaroneck the section along the road exhibits strongly the effects of folding and crushing, with the consequent formation of "Augen" of quartz and of feldspar.

South of Mamaroneck an isolated outcrop of this rock is cut by numerous pegmatite veins, but this was about the only point where this fact was observed.

The minerals forming the gneiss are quartz, plagioclase, biotite, hornblende, orthoclase and in lesser amounts garnet, titanite, zircon, apatite, muscovite and microcline.

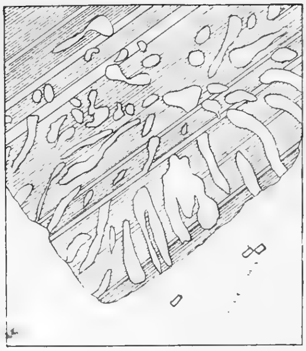
Though macroscopically the rock varies as noted above, microscopically there are no such contrasts observable.*

Quartz. This forms two-fifths to one-half of the rock. It occurs in grains and rounded masses, filling the spaces between the other minerals. The grains are often cracked and show un-

*This variation without a corresponding microscopic one has been noted by A. B. Matthews in the Granites of Pike's Peak, Col. Geol. Soc. of Amer., Baltimore Meeting, Dec., 1894.

dulatory extinction and zonal structure. Dust-like inclusions are often present and are arranged in more or less parallel rows which sometimes extend across the cracks from one grain to another. The quartz also occurs as "Augen" as previously mentioned, but in this case contains few inclusions. Each Auge or eye is made up of a number of grains of different orientation.

Intergrowths with plagioclase are not uncommon, especially around the edge of the feldspar Augen. They are very similar to those figured by La Croix in a gneiss from Ceylon.* Grimsley† and Hobbs‡ have also described the occurrence of micropegmatite in metamorphosed rocks, but the latter finds it in those portions of the rock where mechanical movement has been a minimum, whereas in the Harrison gneiss it occurs in that portion which seems to have been most crushed.



MICROPEGMATITIC INTERGROWTH OF QUARTZ AND PLAGIOCLASE ON BORDER OF ORTHOCLASE "AUGE."

Plagioclase is as abundant as the quartz and in some sections predominates over it. The sections are generally partly állotriomorphic, and usually twinned after the albite law, sometimes in addition after the pericline and rarely after the Carlsbad law. The extinction is about 20°

The twinning lamellæ are often bent and cracked, and the cracks are filled with quartz. Micropegmatite has been mentioned under quartz. While the plagioclase sometimes occurs

* Bull. French Min. Soc., Vol. XII., p. 302, 1859.

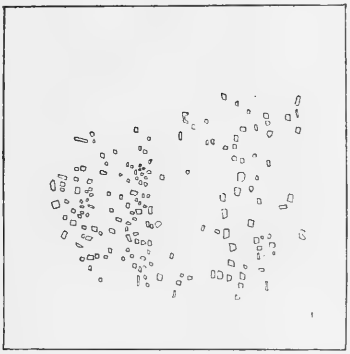
† The Granites of Cecil County, Md.; Journ, Cin. Soc. Nat. Hist., April-July, 1894.

‡ Phases in the metamorphism of schists of Southern Berkshire, Bull. Geol. Soc. Amer. IV., p. 167.

as inclusions in the orthoclase, it is itself almost invariably rich in them; in fact this very great abundance of inclusions is a characteristic feature of the rock. The larger ones are biotite, apatite and zircon, but smaller undeterminable ones are present in countless numbers. They are at times arranged in more or less parallel rows with their longer axes in the same direction. Some of the plagioclases exhibit what are apparently inclusions of feldspar of different composition and with crossed nicols give the crystal a mottled appearance. They may be similar to those described by Hobbs,* but different in that the inclusions do not form a central core.

The plagioclase is usually quite fresh, but in addition to kaolinization sometimes exhibits a dusty alteration product along the cracks and cleavages. Limonite also occurs as an infiltration.

Orthoclase. This is much less abundant than the quartz or plagioclase. It occurs in grains like the quartz. Though noticed



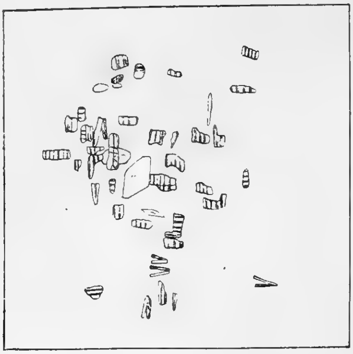
FELDSPAR INCLUSIONS, IN ORTHOCLASE AUGE.

sparingly in most of the sections its chief occurrence is in the "Augen" west of Mamaroneck. These are round or lenticular and .5–1 in. long, and are often Carlsbad twins. Sections show them to be crowded with inclusions of feldspar of two types. First, small ones of square or rectangular outline, with an extinction of 35°-40°, and second, fragments of plagioclase polysynthetically twinned. The former have their sides more or less parallel. They do not extinguish at the same time as their

*l. c.

host but usually in groups. The extinction of the plagioclase inclusions also differs from that of the orthoclase. In addition, there are a few included quartz grains and hexagonal plates of biotite. The two types of feldspar inclusions are usually gathered in groups by themselves.

Lawson has described and figured an almost parallel case from a granite diorite in California,* in which the large Carlsbad



INCLUSION OF PLAGIOCLASE AND BIOTITE (M) IN ORTHOCLASE AUGE.

twins of orthoclase contain numerous inclusions, but their orientation seems to be influenced by the orthoclase. Apart from the Augen the orthoclase does not contain many inclusions. No intergrowths of quartz and orthoclase were seen.

Microcline, though present, is rare. It sometimes occurs in the Augen, containing the same inclusions as the orthoclase, and in some instances seems to be paramorphic after the latter.

While inclusions in feldspar of metamorphosed rocks are not rare and have been noted by Wolff,† Hobbs,‡ Weinschenk§ and others, nevertheless, they do not seem to be so abundant as those in the Harrison granite-diorite.

Prof. G. H. Williams ‖ has described a parallel case from the norites of the Cortlandt Series, in which the plagioclase occurs as inclusions in the orthoclase, and states that when they occur

*Geology of Carmelo Bay, Bull. Dept. of Geol., University of Calif., Vol. I., p. 59.

†Bull. Mus. Comp. Zoöl. XVI., No. 10.

‡l. c.

§Beiträge zur Petrographie der östlichen Central Alpen. Abh. k. Bayer, Acad. der Wiss. II. Classe, XVIII., Bd., III Abth.

‖Amer. Jour. Sci., iii.—XXXIII., 140.

thus they show very irregular shapes as though they had been partially dissolved.

Both the orthoclase and plagioclase are filled with countless numbers of included plates, rods and dots. Prof. Williams notes their resemblance to the trichites of certain volcanic glasses. Their irregularity of direction precludes the possibility of their being solution planes. *Biotite* forms about one-half of the rock. It is green and strongly pleochroic, green to brown. The borders of the crystals are much corroded and the embayments are filled by quartz, which also fits the crystal. The ends of the individuals are frayed, but bending of the lamellæ is rare. *Muscovite* is occasionally present and is sometimes included in the biotite. *Hornblende* is distributed throughout the rock, but is less abundant than the quartz. It exhibits the same corrosion phenomena and quartz inclusions as the biotite.

RUTILE NEEDLES IN QUARTZ, Q; CALCITE, C; BIOTITE, M.

It is strongly pleochroic green to brown. *Garnet* is chiefly confined to the feldspathic portions of the gneiss. *Titanite* is present sparingly and occurs in the usual form or as clusters of rounded grains associated with the biotite. *Pyrite*, though present, is rare, and its disintegration often furnishes limonite. *Rutile* is finely developed in one section from the northern end of the area and its long needles pierce the quartz in every direction. Infiltrated calcite occurs with it. *Sillimanite* also occurs in the schistose facies of the rock.

The large amount of plagioclase present in the gneiss makes it too basic to be called a granite, and therefore the term granite-diorite is more applicable. It is similar in mineralogical composition to the granite-diorite described by Matthew from near St. John, N. B.,* and a quartz diorite described by Grimsley from Cecil county, Md.†

That the Harrison rock has undergone a large amount of dynamic metamorphism is proved by the gneissic and schistose structure, the strained appearance of the minerals, undulatory extinction of the quartzes and cracking of the feldspars. The formation of "Augen" and micropegmatite may also be added.‡ The mica and hornblende which are often pitted with quartz show no such bending or breaking, and it seems not improbable that they are of secondary origin, the result of a recrystallization of the rock.

The age of the intrusion of granite diorite is somewhat a matter of uncertainty. Mather, Dana and Merrill consider that the mica-schists into which the granite-diorite has been intruded are of Silurian age. This would, therefore, make the rock of post Silurian age. It is evident, however, that it received its gneissoid structure during the period of metamorphism which affected the whole of Westchester county.

No good contact between the schist on the east and the granite-diorite has thus far been found. It may be said, however, that near the boundary the schist is seamed with numerous veins of coarse granite and pegmatite.

MINERALOGICAL LABORATORY, COLUMBIA COLLEGE.

The paper was illustrated by maps and specimens and was discussed by the Chairman and Secretary.

The second paper was by N. H. Darton and J. F. Kemp, "The newly discovered Peridotite Intrusion near Syracuse, N. Y."

The paper was discussed by the Chairman and Messrs. Kunz and Martin. It will be printed in full in an early number of the American Journal of Science.

Ten-minute remarks were then made by Professors Martin, Stevenson and Kemp, continuing the discussion of January 21st on the "Condition of the interior of the earth."

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*Trans. N. Y. Acad. Sci., Vol. XIII.

†Jour. Cin. Soc. Nat. Hist., July, 1894.

‡See K. A. Lossen—Ueber Gneiss-granit as Structur-abänderungen der Eruptivgranit Gänge in Harzburger Gabbro, Zeitschr. d. geol. Ges., XL., p. 780.

The final paper was the following:

G. F. Kunz, "The Minerals used in the manufacture of the Babylonian, Assyrian and Sassanian Seals." The paper was illustrated by specimens and photographs and will appear in full in a later number of the Transactions. An abstract has been printed in a recent number of *Science*.

The Academy then adjourned.

J. F. Kemp,
Recording Secretary.

Annual Meeting.

February 25th, 1895.

The Academy met with President Rees in the chair. Twenty-five persons present. The minutes of the last business meeting were read and approved.

Professor W. Gilman Thompson and Mr. Geo. Iles were nominated for resident membership and referred to the Council.

President Rees read the following two papers by title and they were referred to the Publication Committee:

"Mean declination of the 56 stars observed for variation of latitude at Naples and New York," "Parallax of Eta Cassiopeiæ," both by Hermann S. Davis. The reports of officers on the progress of events in the Academy for the year were then presented, and are appended, except that of the President, who gave a verbal review, and those of the Secretaries of the three Sections who reported in the same way.

Report of the Recording Secretary.

During the year there have been held:
8 meetings of the Council.
9 Business Meetings, of which two failed of a quorum.
23 Stated Meetings of the Academy.

1 Public Reception.

7 Public Lectures have been delivered.

The Sections of Biology and Geology have each held eight meetings; that of Astronomy and Physics, nine.

The average attendance at the first has been twenty-five, at the second twenty, and at the third fourteen.

The average of all the meetings has been twenty-five; the largest attendance has been sixty, and the smallest eight.

Papers to the number of ninety-six have been presented, divided as follows:

Anatomy,	1.	General Biology,	16.	Microscopy,	3.
Astrology,	1.	Geodesy,	1.	Mineralogy,	12.
Astronomy,	5.	Geology,	21.	Palæontology,	9.
Botany,	3.	Mech. Engineer'g,	1.	Physics,	8.
Chemistry,	2.	Mechanics,	1.	Zoology,	12.

Ten resident members have been elected. Five have been dropped and six have died, making a total on the Secretary's list of 216, a gain of one during the year. One honorary member and four corresponding members have been added. No fellows have been elected.

Seven signatures and five plates have been issued on volume XIII. of the Transactions, which was completed and mailed to members and exchanges the last of July. Three signatures of volume XIV. have been issued, one is in press, and the fifth awaits sufficient matter to complete it.

Respectfully submitted,

J. F. Kemp,
Recording Secretary.

Report of the Treasurer of the New York Academy of Sciences for the Year Ending Feb. 25, 1895.

RECEIPTS.

Balance on hand at last Annual Report.		
Current Account,	$156.22	
Savings Bank Account,	614.82	$771.04
Interest on Investments and Deposits,		188.82
Initiation Fees,		100.00
Life Membership Fees,		100.00

Annual Dues for 1892,	$70.00	
" " " 1893,	100.00	
" " " 1894,	1,615.00	
" " " 1895,	40.00	$1,825.00
Sales of Lecture Tickets, Course of 1893–4,		12.00
Contributions Towards Expenses of First Annual Reception,	99.35	
Contributions Towards Expenses of Second Annual Reception,	155.00	254.35
		$3,251.21

EXPENDITURES.

Expenses of Publishing Annals, less Sales,	$464.46	
" " " Transactions, less Sales,	497.40	
" " Recording Secretary,	55.04	
" " Treasurer,	33.34	
" " Librarian,	120.89	
" " Lecture Committee, 1893–4,	129.00	
" " First Annual Reception,	235.88	
Janatorial Services,	80.75	
Insurance,	20.00	
Dues to Scientific Alliance,	130.88	1,767.64
Balance on Hand, Current Account,	843.93	
Savings Bank Account,	639.64	$1,483.57

ANNUAL DUES UNPAID.

For 1892,	$20.00	
" 1893,	60.00	
" 1894,	230.00	$310.00

PUBLICATION FUND.

Amount at Last Report,	$1,684.87
Interest Received During 1894,	68.04
	$1,752.91

INVESTMENTS.

United States Four Per Cents. of 1907, $4,100 worth @ 112,	$4,592.00

TOTAL ASSETS.

Cash in Bank,	$1,483.57
Unpaid Dues,	310.00

Publication Fund,	1,752.91
Investments,	4,592.00
	$8,138.48

C. F. COX,
Treasurer.

Examined and found correct by
HENRY DUDLEY,
Chairman Finance Committee.

Report of the Librarian.

Volumes received in exchange for the publications of the Academy, or as donations, have been acknowledged in all cases where this was requested, or whenever in special cases it seemed advisable.

All books and pamphlets received were stamped with the stamp of the Academy, and turned over to the Columbia College Library for binding and shelving.

Eighty-four letters have been written regarding the publications of the Academy.

The following new institutions have been added to our mailing list:

1. Helena Public Library, Helena, Mont., Transactions in exchange for Bulletins.

2. Field Columbian Museum, Chicago, Ill., Transactions in exchange for future publications (nothing yet issued).

3. Colorado College, Colorado Springs, Colorado, Transactions in exchange for "Studies."

4. Australasian Association for the Advancement of Science, Adelaide, S. Aust., Transactions in exchange for "Reports."

5. Victoria Institute, Port of Spain, Trinidad, Transactions in exchange for "Proceedings."

6, Central Meteorological Observatory of Vera Cruz, Xalapa, Mexico, Transactions in exchange for "Bulletins."

39 requests for back Nos. of the publications of the Academy have been received from institutions upon our mailing list.

All these have been supplied, except when some of the publications desired were out of print.

7 individual requests for special numbers of the publications of the Academy have been received. All these have been attended to, and a bill sent in each case. Receipts are given in Librarian's cash account.

2 requests for information in regard to publications have been received and answered.

175 acknowledgments have been returned by mail.

14 packages, including 63 individual enclosures separately, have been sent by express.

6 new Institutions have been added to the mailing list.

All correspondence, with memoranda in regard to reply, has been preserved.

The space now available for shelving the library in the room occupied by it, in Columbia College, has about reached its limit. The Council have authorized a committee consisting of the Librarian and Dr. Britton to confer with the Librarian of the College in regard to the matter.

ARTHUR HOLLICK,
Librarian.

In behalf of the Audubon Monument Committee, Professor Britton explained that the stone-cutters had not yet provided an acceptable base, and he therefore asked that the committee be continued. On motion this was done.

The Secretary presented the following preamble and resolution regarding the preparation of a topographical map of the State.

NEW YORK ACADEMY OF SCIENCES,
41 East 49th St.,
New York, N. Y., March 4, 1895.

To the Honorable —. —. ————,
Assembly Chamber, Albany, N. Y:

MY DEAR SIR :—At a recent meeting of the New York Academy of Sciences the following preamble and resolution was passed :

" WHEREAS, The New York Academy of Sciences appreciates that a good topographical map, of a suitably large scale, of the

State of New York is imperatively needed, and that the neighboring States, New Jersey, Connecticut, Rhode Island and Massachusetts are already provided with such maps, which have been made with the coöperation of the United States Geological Survey, and which are now on sale throughout those States at very reasonable rates, to the benefit of the people ; and

WHEREAS, In its judgment, this work in New York should be under the supervision of the State Engineer and Surveyor, as the proper State official, and it is undesirable to create a new and separate official for this specific purpose, and inasmuch as the United States Geological Survey is ready to coöperate with the State Engineer in making these maps;

Resolved, That the New York Academy of Sciences urges upon the Hon. Danforth E. Ainsworth, Chairman of the Committee on Ways and Means, and upon the representatives of the city, the importance of bringing the bill, No. 507, recently introduced for this purpose by the Hon. Wm. Cary Sanger to an early passage."

Yours respectfully,

J. F. KEMP,
Recording Secretary.

On motion the Secretary was authorized to draw on the Treasurer, for the expenses of duplicating and mailing the resolution.

It was moved and carried that the President be authorized to appoint a committee to take in hand the raising of money for the publication fund of the Academy. The President subsequently appointed Messrs. Osborn, Cox and Rees.

The Secretary presented a communication from the Finance Committee relating to the management of the invested funds of the Academy, and on motion it was referred to the Council.

The Academy then proceeded to ballot for officers for the ensuing year, and the election resulted in the selection of the appended list:

President—J. K. Rees.

1st Vice-President—H. F. Osborn.

2d Vice-President—J. J. Stevenson.

Corresponding Secretary—D. S. Martin.

Recording Secretary—J. F. Kemp.

Treasurer—C. F. Cox.

Librarian—Arthur Hollick.

Councillors—J. A. Allen, Bashford Dean, N. L. Britton, William Hallock, William Stratford, R. S. Woodward.

Curators—H. G. Dyar, G. F. Kunz, L. H. Laudy, Heinrich Ries, W. D. Schoonmaker.

Finance Committee—Henry Dudley, J. H. Hinton, Cornelius Van Brunt.

The Academy then adjourned.

J. F. Kemp,
Recording Secretary.

Regular Stated Meeting.

March 4th, 1895.

The Academy met with President Rees in the chair.

The reading of the minutes was postponed until the next business meeting. On motion, the following names nominated for resident membership and recommended by the Council, were elected:

Dr. Livingston Farrand.
Prof. W. Gilman Thompson.
Mr. George Iles.

The Academy then listened to the Fourth Public Lecture of the course of 1894–95, by Prof. Wm. Hallock, on "Bolometric Researches in the Infra-red Spectrum of the Sun."

Seventy-five persons were present.

The Academy then adjourned.

J. F. Kemp,
Recording Secretary.

Stated Meeting.

Monday, March 11th.

In the absence of regular business the Biological Section at once organized; Prof. Britton in the chair; an attendance of fifteen. The minutes of the preceding meeting of the Section were read and approved.

A paper was presented by Mr. A. P. Matthews "On the Mechanism of the Secretion of Gland Cells," recording his observations on the cells especially of the pancreas. In the discussion which followed Prof. Curtis, Dr. Lee and Prof. Osborn took part.

NOTES ON CERTAIN VARIATIONS IN THE BIOLOGICAL CHARACTERS OF TWO SPECIES OF BACTERIA.

By Harrison G. Dyar, A. M.

In no other group of plants or animals are the so-called "biological" characters relied on so completely for the separation of species as in the bacteria. It is evident, from an examination of the published descriptions, that the characters in general use are often not sufficient to afford satisfactory distinctions between the species. Other characters will have to be added, and, as only biological ones seem available, I have collected the following notes to give some idea as to what extent of variation is to be expected in the growth forms and products in the commoner media of cultivation.

I have selected two microörganisms commonly occurring in ing in the air of New York City, both of which can be recognized by their distinctive colors.

Merismopedia Rosea (Bumm.)

Synonomy.—Diplococcus roseus Bumm, Der. Mik. der Gon. Schleimhauterkrank, p. 25, 1885. *Micrococcus roseus*, Eisenberg, Bak. Diag., p. 408, 1891. *Micrococcus tetragenus ruber*, Schneider, Inaug. diss., Basel, p. 21, 1889.? *Sarcina rosea*, Lindner. Die Sarcineorg. der Gährungsw., Berlin. 1888.

Occurrence.—(1) A culture received from Král's bacteriological laboratory at Prague, marked "M. tet. ruber." (2) A culture in the collection of the Bacteriological Department of Columbia College, marked "Sarcina rosea. (3) The most common species on some plates exposed in the hallway of the 59th street building, November 16, 1893. (4) In the air of my flat, W. 69th street. (5) A contamination from the air of the laboratory on certain plates.

In this species the cells divide in two directions, forming diplococci and tetrads, and it is consequently referable to the genus Merismopedia. In the state of early division a hemispherical appearance of the elements may be noted which is described by Bumm as a resemblance to the "gonococcus." Eisenberg does not describe the cells as associated in pairs and fours, but this appearance may not always be well marked.

Sarcina rosea is evidently closely allied to this species, but I do not venture to consider it identical, as it is described as a true Sarcina, and is said to liquefy gelatin rapidly. But neither of these characters are of great value when the exact composition of the media is not known.

Variation in Biological Characters.

Liquefaction of gelatin.—Culture 1 produced the first signs of liquefaction in 14 days. Culture 3, after it had been in cultivation some months, produced distinct liquefaction in 10 days. The same culture, when freshly obtained from the air, produced no liquefaction as long as the tube was retained (40 days). Culture 5 produced no liquefaction at first (30 days), but in a second culture traces of liquefaction were observed in 30 days, and in another later one in 19 days. In culture 5, hollows sinking into the surface of the gelatin, indicating liquefaction, were observed in 50 days. In culture 2, no sign of liquefaction was obtained till 30 days, although this culture had been in cultivation in the College collection for some time.

Action on Milk.—None of the cultures produced any coagulating effect in milk, before or after boiling. Usually a fine pink growth of the cocci was obtained.

Reduction of Nitrates.—The effect of the growth of this organism in the "nitrate solution" is to produce a moderate amount of reduction to nitrite. The test never yields more than a fairly strong pink color. The following are the variations observed: Culture 1 gave a very faint color in 4 days, faint in 10 days, and quite a strong tint in 28 days. Cultures 2 and 3 produced a faint color quite uniformly at different times from 6 to 28 days. Culture 5 produced a faint trace only at the end of 28 days, and culture 4 produced no reduction of the nitrate.

Growth on Potato.—Quite often the cocci will not grow on this medium; again a slight growth may be observed. Culture 3, however, grew well, producing a considerable mass of growth of a slimy pale pink in 17 days.

Color.—Practically no variation was observed in the characteristic pink color of the growth masses of this coccus. There seems to be no tendency toward a permanent white form on repeated cultivation. Grown at $37\frac{1}{2}°$ C., growth is poor and without color, but the pink tint is regained after the culture has been removed to the room temperature.

Bacillus Lactis Erythrogenes (Hueppe).

*Synonymy.**—*Bacillus lactis erythrogenes*, Hueppe, Fortschr. der Med., Vol. VII., p. 141, 1889.

Bacillus versicolor, Prudden, Proc. N. Y. Pathological Soc., 1889, p. 103.

Bacillus helvolus, Zimmermann, Die bak. unser Nütz-u. Trinkw., Part I., 52, 1890.

Occurrence.—(1) Cultures from the collection of the Department of Pathology, Coll. P. & S., of Columbia College. (2) In the air in different parts of the college building, 59th st., in the yard on 59th st., in a barn (Dr. Freeman). (3) In the air of my flat W. 69th st. (4) In the yard, 59th st., Oct., 1894. (5) Same as 4. (6) Same. (7) A culture from Král, marked "B. helvolus."

Variation in Biological Characters.

Liquefaction of gelatin.—Liquefaction usually begins in from 3 to 6 days; in about half the cultures in 3 days. In culture 3 no liquefaction was obtained till 33 days, when a dry hollow was observed to have been formed; but on preparing a second culture from this tube, liquefaction set in in 15 days, and was well marked in 20 days.

The degree of acidity of the medium has an effect on the rapidity of liquefaction, as shown by the following table: (Cultures all made from the same tube of culture 3.)

The optimum degree of acidity for this species seems to be about .15 cc. of tenth normal sodium hydrate solution acid per cc. to phenol-ptalein (distinctly alkaline to litmus). But in another instance, where two cultures were made from the same tube (culture 1) in two tubes filled with .4 acid gelatin, under the same conditions, one did not liquefy for 10 days, while the other began to liquefy in 4 days. Perhaps this difference may have been due to a difference in the number of bacteria on the innoculation needle.

* These names may be used to indicate varieties.

GELATIN.	1 Day.	2 Days.	4 Days.	6 Days.	8 Days.	9 Days.	Rel. Adv.†
.17 cc. Alkaline*.	No liquef.	No liquef.	Cup-shaped.	Deeper cup.	Little funnel.	Liq. on surface.	│
.10 cc. Alkaline .	"	"	"	"	"	Funnel.	│
Neutral	"	"	"	"	Deep cup.	"	│
.10 cc. Acid . . .	"	"	"	. . . . . .	Liq. on surface.	Well liquef.	│
.18 cc. Acid . . .	"	"	"	Cup-shaped.	Deep cup.	Liq. part surface.	│
.25 cc. Acid . . .	"	"	No liquef.	No liquef.	Just liquef.	Cup-shaped.	│
.40 cc. Acid . . .	"	"	"	"	. . . .	Small cup.	│

* This means that each cc. of the gelatin requires .17 cc. of tenth normal acid to render it neutral to phenol-ptalein.

† The distance of the bar to the right, in this column, indicates the relative advance which the respective growth had made.

Action on Milk.—According to the descriptions, in milk "the casein is slowly precipitated, and later is peptonized with a neutral or alkaline reaction." This is the usual course; but there is never a distinct coagulum, even on boiling. The milk usually assumes a watery appearance, with a slight amount of white sediment, which is gradually dissolved. Cultures 3, 5 and 7 produced no perceptible change in milk; again in 3, a slight sediment was observed, but no coagulum on boiling. Culture 6 rendered the milk very watery. In appearance the contents of the tube were two-thirds of a watery fluid, colored pink and one-third of a flaky coagulum; but on shaking up and boiling, the coagulum was seen to have no consistence.

Reduction of Nitrate.—Nitrates are usually quickly and thoroughly reduced to nitrite, the test giving a dark red color in 6 days. In culture 3 the dark color was not obtained till the 26th day, the test resulting in a faint color before that date. In culture 6 no reduction was observable till the 14th day, and at the end of 28 days the test gave only a faint color. In cultures 4 and 7 there was practically no reduction of the nitrate, the test only giving a trace of color at the end of 25 days.

Color.—The normal appearance is a light yellow color of the mass of growth, accompanied by a fine pink tint throughout the medium. Where the species occurred abundantly in the air, a considerable difference was observable in the shade of yellow of the different colonies growing on a single plate, and this was also observable in the various cultures obtained. The color varies from nearly white to rather dark yellow. I have a culture which has become entirely white from repeated cultivation, though retaining the pink tint apparently undiminished. There is also variation in the opacity of the growth. In culture 5, the yellow color was bright, but the pink tint scarcely perceptible. In 3, after cultivation for some months, the pink became very faint, though distinct at first. In culture 7, no pink tint was discernible when received, but after cultivation for some months it became quite well marked. In 6, the growth was white with a yellow tint only, but a fine pink color in the medium.

I have considered all cultures to belong to *Bacillus lactis erythrogenes* that exhibited both the yellow and pink tints in some degree, and which liquefied gelatin, at least finally; but I possess cultures in which there is no pink tint discernible, some of which liquefy gelatin, and others not. Are these all good species or only slightly further varieties of *Bacillus lactis erythrogenes?* The forms may be tabulated thus, in regard to the most salient features:

Mark.	Gelatin.	Milk.	Nitrate.	Color.
BH	Not liquefied.	Not coagulated.	Not reduced.	Yellow.
BR	" "	" "	Test gives a faint color.	"
BO	Liquefied in 14 d.	" "	Very faint color.	"
CN	" "	" "	Reduced.	"
CK	Liquefied in 21 d.	" "	Trace.	White.

In the absence of Profs. Allen and Huntington no further papers were presented.

Prof. Osborn spoke of the communication of the Royal Society regarding the collection of references of recent publications, and, after discussing the especial need for this projected work, moved: That the Chairman of the Biological Section of the Academy be empowered to appoint a committee of three to report on the steps that might be taken to aid in the work of the Royal Society. The motion was carried. Prof. Britton subsequently appointed as members of this committee, Prof. H. F. Osborn, Prof. Wm. Stratford and Prof. J. J. Stevenson.

Another motion was carried inviting Prof. E. B. Wilson to present his studies on the "Fertilization Phenomena of Toxopneustes" at the next meeting of the Section. The paper of Prof. Huntington was, at his written request, deferred until the next meeting.

BASHFORD DEAN,
Rec. Sec. of Biol. Sec.

STATED MEETING.

March 17th, 1895.

The Academy met with Vice President STEVENSON in the chair, twenty-six persons present.

The minutes of the previous meeting were read and approved.

Prof. Britton mentioned the recent death of Mr. J. H. Redfield, of Philadelphia, one of the oldest members of the Academy, and suggested that a committee be appointed to prepare a suitable memorial. On motion, this was carried and the chair appointed Messrs. Britton, Julien and Martin.

Dr. Julien brought before the Academy a circular in reference to the Relief Expedition for Lieutenant Peary, and suggested that the Academy contribute to the fund.

On motion, the matter was referred to the Council.

The Section of Geology and Mineralogy then organized and elected the following sectional officers for the ensuing year:

Chairman, PROF. J. J. STEVENSON.
Secretary, PROF. J. F. KEMP.

The first paper was by Prof. J. J. Stevenson, "The Origin of the Pennsylvania Anthracite." Discussion followed by Messrs. Britton, Julien and Kemp.

The second paper by Dr. Wortmann was postponed one month. The Secretary read by title the following papers, which were referred to the Publication Committee:

G. F. Matthew, "The Protolenus Fauna."

W. D. Matthew, "Effusive and Dike Rocks near St. John, N. B."

H. Ries, "Pyroxenes of New York State."

N. Banks, "Spiders of Colorado."

The first of these papers appears below, and the last will be published in the Annals.

The Academy then adjourned.

J. F. KEMP,
Recording Secretary.

ERRATA IN "THE PROTOLENUS FAUNA."

p. 102. Next to last paragraph, 2d line, "has" not "have."

p. 109. 1st line should read "conditions resulted in the."

p. 109. Second paragraph, last line should read "of this group, the Foraminifera."

p. 110. 7th line, after "b" insert "Assise 2."

p. 111. After "GLOBIGERINA GRANDIS n. sp. Pl. I., fig. 6," insert "This species is closely related to the preceding, but is larger, the final chamber being especially large. It was composed of four chambers, of which the first three are arranged lineally or nearly so."

p. 115. First paragraph, last line, delide "inner." After "value," add "on the under side."

p. 126. 11th line delide "Band."

p. 148. Under Brachiopoda, after Obolella nitida, Ford, insert (?).

Also in description of Pl. II., fig. 8, insert (?) after Obolella nitida, Ford.

THE PROTOLENUS FAUNA.

By G. F. Matthew, Corresponding Member.

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Introduction.

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Forminifera — Spongida — Brachiopoda—Mollusca—Ostracoda—Phyllopoda—Trilobita.
List of species, localities and horizons.

Comparisons and conclusions.

Distinctive characters of the Fauna.
Its probable relations to the Olenellus Fauna.

Some of the material collected by an exploring party from Columbia College, New York, conducted by Mr. Gilbert van Ingen, having been placed in my hands for study, this I have examined and give the result in the following pages.

The material under examination was all collected from Band *b* of Division 1 of the St. John Group and was studied in connection with other material in my hands, previously collected from the same zone by W. D. Matthew and the author.

Investigations of the Cambrian faunas by the present writer have been principally confined to those of the Atlantic Basin, the only part of the world where thorough work has been done on the organic remains of this age. Sporadic representatives of the Cambrian types of animal life have been gathered from South America, Australia, India, China and Siberia, but none of these give that comprehensive view of the succession of living forms in that distant period which can be gathered from a study of the Atlantic Cambrian faunas.

A good deal is known of the faunas of this age that occur in the Cambrian strata in the west of the United States, owing to the admirable work done in that section of the Union by the officers of the United States Geological Survey; but, nevertheless, the Cambrian rocks of the Atlantic Basin remain the standard for determining the succession of faunas, and for the comparison of their facies.

Taking these faunas and these deposits as the standard, we regard the arrangement and division of the Cambrian faunas set forth by Messrs. Salter and Hicks many years ago as presenting the most natural arrangement of the Life Zones of this System. By this arrangemement the Cambrian is divided into two great sections, the lower holding the "Great Oleni" (Paradoxides, Olenellus, etc.), the upper the depauperated forms, Olenus (proper), Peltura, etc. Under this arrangement of the Cambrian System we have the following faunas of trilobites (descending order).

	In Scandinavia.	*In Wales.*
Upper Cambrian.	Ceratopyge Fauna,	Upper Tremadoc,
	Peltura Fauna,	Lower Tremadoc,
	Olenus Fauna.	Lingula Flags.
Lower Cambrian.	Paradoxides Fauna,	Menevian and Solva,
	Olenellus Fauna.	Caerfai Group.

Each of these faunas is well characterized and the three middle ones have several sub-zones. This arrangement in sub-zones has not been shown to exist in the Olenellus Zone, but as there is such a variety of forms grouped under Olenellus in its comprehensive sense, it it quite probable that such sub-zones exist.

One advantage of the localization of the study of the Cambrian in Southern New Brunswick is that it has enabled us to point out the existence of several sub-zones in the fauna which there came in before Paradoxides, but which apparently is not the Olenellus Fauna, since this genus *does not occur*, and the species associated with Olenellus are also mostly wanting.

A knowledge of the grand zones of life in the Cambrian of the Atlantic coast of America have been developed by slow degrees. The Paradoxides zone was first made known, many years ago, on the discovery of *P. Harlani* in Massachusetts; this was followed soon after by the discovery of the same genus in Newfoundland, and after some years in New Brunswick.

Next in order was the Olenellus Zone, though for many years its true position was misunderstood, and it was determined for America only when Mr. Walcott found it in subordinate position to the Paradoxides Zone at Manuel Brook, in Newfoundland.*

*The writer had previously determined this to be a Pre-Paradoxides Zone (and gave the name of "Horizon of Agraulos strenuus") from specimens sent him by Mr. J. P. Howley, the present director of the Geological Survey in that island. At that time the zone was not known to contain any representative of the genus Olenellus. Trans. Roy. Soc. Can., Vol. iv., sec. iv., p. 148.

The Peltura Fauna was recognized by J. W. Salter as existing in the Island of Cape Breton, in Nova Scotia, from certain fossils taken to the Great Exhibition in London (1851?) by the late Dr. D. Honeyman. It was not recognized in New Brunswick until 1891.

One more of these trilobite faunas of the European Cambrian rocks has just been found on this side of the Atlantic, viz., the Olenus Fauna. This occurs at Random Island, in Newfoundland, where Mr. Howley made some explorations last summer. He sent me some fossils from that island for examination, and among them were two examples of an Olenus. There remains now, therefore, only one fauna of the European Cambrian rocks that has not been recognized on this side of the Atlantic, the Ceratopyge Fauna, or that found in the Upper Tremadoc slates of Wales.

Whether we consider the thickness of the sediments in the several parts of the Atlantic Basin (omitting such adventitious additions as lava flows and volcanic ashes, or the coarse conglomerates of an immediate coast line), or whether we regard the kind and succession of the faunas which the Cambrian rocks contain, we are justified in giving more weight to the Upper Cambrian than is implied in the division into three sections of Upper, Middle and Lower.

Furthermore, it is time that a *base be found for the Cambrian*. Already has one faunal zone been added which was not in the life zones originally known as Cambrian, viz., the Olenellus Zone; and if this process continues, each new country will add its Cambrian fauna from among the oldest Palæozoic sediments, until Cambrian will include "all below."

On this side of the Atlantic, at least, we have what is a definite base to the Cambrian (if it will be accepted as such) in a sandstone bed at or near the horizon of Olenellus. Near shorelines this sandstone may become a conglomerate as at Manual Brook, elsewhere only a limestone may show, as at Brigus and Topsail Head, but generally in Newfoundland, as well as in New Brunswick, a pure sandstone holds the lowest position in relation to the Cambrian Faunas. No fauna of trilobites has yet been found below this sandstone. Here then should the line be drawn between Cambrian and pre-Cambrian.

Above this limit there have thus far been found on the Atlantic coast of America the following trilobite faunas:

Upper Cambrian	Peltura Fauna. Olenus Fauna.
Lower Cambrian	Paradoxides Fauna. Olenellus Fauna.

Above this limit also is another fauna, whose relation to Olenellus is not quite clear, but is a very close one. This is the Protolenus Fauna.

A number of the species of this fauna have already been described by the author in the Transactions of the Royal Society of Canada and the Bulletin of the Natural History Society of New Brunswick,* but the present paper will considerably enlarge the number of species.

A valuable feature in the work of Mr. W. D. Matthew in 1892, '93 and '94 and of Mr. G. Van Ingen in 1894 is that they carefully noted the special horizons from which the fossils collected by them came. This has enabled the author to distinguish several sub-zones, each characterized by its own assemblage of fossils, and permitted him also to show, with more exactness than had previously been possible, the relation of each species to the particular kind of sediment in which it is found. One can thus present, in a clearer light than heretofore, the life of the Cambrian Time prior to the advent of Paradoxides, and show that there was a fauna of trilobites of this age independent of that which accompanied Olenellus, one which was more pelagic in its facies and also consisted of forms that in some respects were more primitive.

THE CAMBRIAN TERRANE IN NEW BRUNSWICK.

To make clearer the relation of the groups of fossils which the writer proposes to describe in this paper to the fauna of the Cambrian system as a whole in Eastern Canada, a brief outline will be given of the discoveries which have been made in the Cambrian terrane in New Brunswick.

It was in 1865 that Prof. C. F. Hartt, by comparing the collections made by the Geological Survey of New Brunswick with Barrande's figures and descriptions of the Primordeal Fauna, was enabled to announce the presence of that fauna in Southern New Brunswick. Nothing further was done with these faunas until the author resumed their study in 1881. Hartt's discovery was of the Lower Paradoxides Fauna, and it was not until 1885, twenty years later, that the Upper Paradoxides Fauna† was found. About 1890 an Arenig Fauna, "Quebec Group," was found, and a year later that of *Dictyonema flabelliformis.*

These discoveries showed that the St. John group contained not only the full series of Cambrian deposits, but a part of the Ordovician system as well.

*Trans. Roy. Soc. Can., Vol. vii., sec. iv., p. 135; Vol. xi., sec. iv., p. 85.
Nat. Hist. Soc. N. Brunswick, Bull. 10, p. 34.

†I use the term "upper" here relatively, because on this continent no higher has been found; it is the middle Paradoxides Sub-Fauna of Europe.

The details of these investigations and results are contained in a series of articles in the Transactions of the Royal Society of Canada and in other periodicals; and as far as the series of Life Zones are concerned may be summarized as follows (in descending order):

St. John Group.	Division 3. Bretonian.	Band *d*	Fauna of Tetragraptus quadribranchiatus.	
		" *c*	" " Dictyonema flabelliformis.	
		" *b*	" " Peltura scarabeoides.	
		" *a*	" " Parabolina spinulosa.	
	Division 2. Johannian.	" *c*	" " Lingulella radula	place of the Olenus Fauna.
		" *b*	" " L——— Starri	
		" *a*	" "	
	Division 1. Acadian.	" *d*	" " Paradoxides Abenacus *cf.* Tessini.	
		" c^2	" " P———Eteminicus *cf.* rugulosus.	
		" c^1	" " P———lamellatus *cf.* oelandicus.	
		" *b*	" " PROTOLENUS. (found in *b* 2 and *b* 3.)	
		" *a*	No fauna known.	

Beneath the St. John group is an older set of strata (Etcheminian), which formerly the author was disposed to think might contain the Olenellus Fauna, a fauna which, according to Walcott, is spread through a great thickness of beds in certain parts of the Cambrian deposits in the western part of North America. This, however, does not appear to have been the case on the eastern borders of that continent, either in Massachussetts or Newfoundland, but like Paradoxides and Protolenus it occupies a comparatively thin zone. We suppose therefore that the mass of sediments directly below the St. John group is actually Pre-Cambrian.

In Newfoundland this underlying series or terrane present, precisely the same appearance as in New Brunswick, except that in some districts it is more calcareous. In both countries it is composed of a great thickness of red and green or greenish gray slates or shales, very uniform in appearance and having but a meagre fauna, mostly animals of a low type of structure, as Protozoans, Brachiopods, Echinoderms ? and Molluscs; worm burrows and trails being plentiful in the coarser beds. In New Brunswick there is a definite base of conglomerates to this series, but in Newfoundland the base has not been shown. Olenellus having been found in Newfoundland above this series, the series is there clearly Pre-Cambrian.

The Olenellus Zone, though diligently sought for, has not yet been recognized in New Brunswick. About ten years ago two trilobites in an imperfect condition, even as regards the head-shields, were found in the Pre-Paradoxides beds, and several smaller crustaceans, as well as brachiopods and other fossils, but these did not give satisfactory proof of the fauna to which they belonged, and in 1892 Mr. W. D. Matthew, at the author's suggestion, began a more careful and detailed examination of the strata of the St. John group underlying the Paradoxides beds. This investigation was not without reward, for it resulted in the discovery of several new species of trilobites and of other crustaceans, brachiopods, etc., which showed that the fauna was a new one, different from any that had been described.

The chief merit of the explorer's work was that he carefully distinguished the fossils that came from the different assises of the Sub-Paradoxides beds and was thus enabled to show that three distinct subfaunas were present in these underlying beds of Band *b*. The stratigraphical features of these assises had already been indicated by the writer, there being five of them, and the two subfaunas found by W. D. Matthew were in Assises 2 and 3, the fauna of Assise 1 having been already partly made known by the present author.

Numbered from below upward, there are the following subfaunas in these several assises:

1. Subzone of Hipponicharion eos (Ostracod).
2. " " Protolenus elegans.
3. " " Protolenus paradoxoides.
4. " " Beyrichona tinea (Ostracod).
5. " Crustacean fauna unknown.

None of the trilobites pass from one of these subzones to the other, and few of the other crustaceans.

The species collected by the author and by W. D. Matthew from Band *b*, between the years 1881 and 1893, were the more common or more easily recognized species; whereas a number of those collected last summer were either rare species that had not been previously obtained, or parts of species already in hand, of which the material obtained in earlier years was imperfect, and the species had therefore been left undescribed. From this point of view it will be seen that the collections made last year for Columbia College are a clear gain to science, as the author has thus been enabled to describe several crustaceans and other forms, which without the additional information thus obtained could not have been presented.

SECTION AT HANFORD BROOK.

Among the various exposures of the Cambrian rocks in southern New Brunswick there is none which shows more clearly the succession in the lower part of the System than the section on

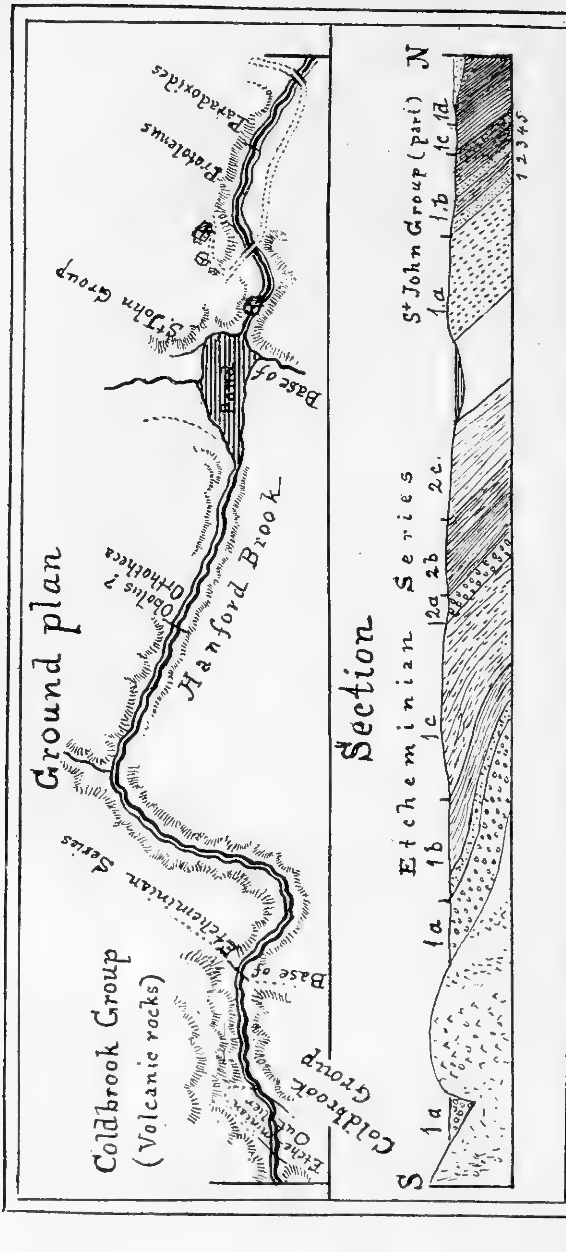
Hanford Brook. This stream runs at right angles to the strike of the beds for a considerable distance, and exposes the whole Paleozoic base, from the oldest conglomerates of the Etcheminian series to the Upper Paradoxides beds. It thus includes the Protolenus Zone, and shows clearly the relation of this zone both to the overlying Paradoxides beds, and the underlying barren sandstone which is at the base of the St. John group; and thus also its relation to the still older, unconformable, Etcheminian series.

The Palæozoic rocks, of which the above series is the lowest member in this region of the world, rest upon a great series of volcanic rocks—lava flows, ashes and breccias which are spread over a wide extent of country in this part of New Brunswick. When the Etcheminian deposits began, areas of these volcanic rocks, and of older clastics, were above the sea and furnished the necessary materials for the conglomerates which form the base of the Etcheminian. These conglomerates are composed partly of the debris of the volcanic rocks, but largely of rolled quartz pebbles which have been derived from the quartz veins of the earlier clastics—Huronian and Laurentian, of which exposures now exist to the north and northeast of Hanford Brook.

Happily, the exposures along this stream are complete, so that the St. John group (lower part) can be traced down to its base in the barren sandstone, *a*, and the older Etcheminian to its base in the conglomerates mentioned above. The relative position of the Protolenus Fauna is readily apprehended by an examination of this section. (See page 108.)

Explorations made by Mr. J. P. Howley, Director of the Geological Survey of Newfoundland during the past summer, have revealed the presence there of a series of Palæozoic deposits similar to that on Hanford Brook, but of greater thickness. The Etcheminian Series is found there as a thick deposit of red slates occurring along the shore of Random Sound, and overlain by a sandstone band which, with the accompanying shales, are equivalent to the section on Manuel Brook containing Olenellus and Paradoxides. Here also is found, what has not heretofore been discovered in eastern North America, except at St. John, viz.: a clear succession of beds from the Lower to the Upper Cambrian. In the latter were found the Oleni referred to on a previous page.

These Olenus beds in their micaceous surfaces present a condition parallel to that of the strata of Division 2 of the St. John Group; and there is great reason to suppose that a similarity of physical conditions prevailed over an extensive region along the Atlantic coast of North America in Etcheminian and



Ground plan and section, to show the relation of the **Protolenus Zone** to the underlying and overlying rocks at Hanford Brook, St. Martin's N.B.

Cambrian times. This similarity of conditions the resulted in deposition, first of the great series of red and green sediments of Pre-Cambrian age, then of the slates or shales (based upon a sandstone member), which contain Olenellus and Paradoxides in one country and Protolenus and Paradoxides in the other, and then of the flags and shales that hold the Olenus Fauna.

These similar series of deposits are now found remote from each other, and in small isolated basins; but we are not therefore to assume that there may not originally have been a much closer connection between them, by means of areas of sediment either not now recognizable, or not now existing. The great dynamical movements that have occurred in this region since Cambrian time, the metamorphism of large tracts in the intervening space, and the enormous denudation that has supervened, all will have helped to remove the proof of such possible direct communication between the Cambrian rocks of Acadia and Newfoundland.

Descriptions of the Species.

FORAMINIFERA

The first notice of remains of this group of the Protozoa in these Cambrian rocks is that in connection with W. D. Matthew's article on Phosphate Nodules from the Cambrian of Southern New Brunswick.* In this article are several plates of the objects seen in microscopic sections of these nodules, and among them are several forms which we can now clearly see, are of this group, of the Foraminifera.

Small shells of this order have not only been found in the phosphate nodules, but occur scattered over the surface of the shales, in which they are well preserved, owing to the firm calcareous nature of their tests at the time of their entombment. All observed belong to the Perforata. Possibly other groups of Foraminifera are present, but such as have arenaceous coatings are not easily detected owing to the siliceous particles in the slate, its hardness, and the partial metamorphic change which it has undergone by the infiltration of chemical solutions. Most of the forms observed belong to the Globigerinidæ.

ORBULINA cf. UNIVERSA, Lam. Pl. I., fig. 1.

See "Phosphate Nodules" Pl. 1., Figs. 13 (& 15?).

The commonest species of the Globigerinidæ occurring in these shales is one which cannot be distinguished either by size

*Trans. New York Acad Sci. Vol. xii., 1893, p. 108, pl. 1, 2 and 3.

or external features from the prevalent type of this genus in the modern ocean. Some show traces of an oral opening.

Sculpture. A strong lens develops a pitted surface on these fossils.

Size. Diameter about $\frac{1}{2}$ mm.

Horizon and locality. The olive green shales of Div. 1., Band b, at Hanford Brook, both in the shaly matrix and in phosphatic nodules. Apt to occur on certain layers, but not generally diffused through the shale.

ORBULINA (?) OVALIS, n. sp. Pl. I., fig. 2.

See "Phosphate Nodules" Pl. 1. Fig. 20. Pl. 2. Fig. 7.

A small species of the size of *O.* cf. *universa* but of different form. The tuberculation is very fine and there is a trace of an orifice at one end.

Size. Length about $\frac{3}{4}$ mm. Width about $\frac{1}{2}$ mm.

Horizon and locality. As the preceding. Scarce.

ORBULINA INTERMEDIA, n. sp. Pl. I., fig. 3.

This species differs from *O.* cf. *universa* in its larger size, and also in frequently having ridges or rugosities on its surface. These ridges often begin near a small depression on the surface of the shell, supposed to be the mouth.

Sculpture as in *O.* cf. *universa.*

Size. Diameter 1 to $1\frac{1}{4}$ mm.

Horizon and locality. As the preceding two, but not of such common occurrence as the first.

ORBULINA (?) INGENS, n. sp. Pl. I., fig. 4.

Differs only in size from the two preceding, and is not so common.

Sculpture. It appears to have large pores scattered over the surface as well as the numerous, small, closely set pores. Some examples have ridges and inequalities on the surface as in the preceding species.

Size. Diameter $1\frac{3}{4}$ mm.

Horizon and locality. As the preceding.

The size of the the species leads one to suspect that it may be a globigerine form in which the primary cells are entirely enveloped by the final cell, as in some forms described under Globigerina.

GLOBIGERINA CAMBRICA, n. sp. Pl. I., figs. 5 *a* to *c*.

See "Phosphate Nodules" Pl. 1, figs. 8 and 17; Pl. 3, fig. 8?

Multilocular, variable in the position of the first chambers. Sometimes two of these are visible within the final chamber, and one without, in other cases all three (or four?) are external to the final chamber.

Sculpture. The surface is marked with numerous minute pits, only visible with a strong lens.

Size. Diameter including the final chamber 1 to 1½ mm.

Horizon and locality. As the preceding.

This species differs from the more modern (Pliocene) *Globigerina conglomerata*, Schwager, in the fact that the chambers do not connect with each other, and there is not the same gradation of size in the chambers. No more than four chambers have been observed in this species, and when they are all external they are frequently found detached from the final cell, leaving a cup-shaped depression on its surface. The final chamber is always much larger than the others.

GLOBIGERINA GRANDIS, n. sp. Pl. I., fig. 6.

(SEE ERRATA, OPP. P. 100)

Sculpture. As in the preceding species.

Size. Diameter 2 mm.

Horizon and locality. As the preceding.

GLOBIGERINA DIDYMA, n. sp. Pl. I., figs. 7 *a* and *b*.

See "Phosphate Nodules," Pl. 1, figs. 1 and 4? Pl. 2, fig. 9.

Multilocular, probably consisting of four chambers, of which the two final ones are of nearly equal size. There is an arched mouth at the edge of the final chamber, on the opposite side from that whereon the small primary chambers are situated.

Sculpture. As the preceding.

Size. Diameter, short 1½ mm.; long 1¾mm.

Horizon and locality. As the preceding.

GLOBIGERINA TURRITA, n. sp. Pl. I., figs. 8 *a* and *b*.

"Phosphate Nodules" p. 114, Pl. 3, figs. 5 and 7.

Multilocular, cells linear in arrangement, or nearly so, regularly increasing in size.

Size. Length 1½ mm.; width nearly 1 mm.

Horizon and locality. Shales of Assize 2 in. Band *b*. Scarce.

This form was obtained by W. D. Matthew in sectioning phosphate nodules.

SPONGIDA.

The reference of a number of objects to this group has been made for the purpose of calling attention to remains which contain sponge spicules, but which are often in such imperfect preservation that they cannot satisfactorily be referred to known genera. Even Protospongia as defined by Salter is not of generic value; for Mr. C. D. Walcott studies on the Utica slate forms (first described at Cyathophycus), and Sir. Wm. Dawson's observations on the Ordovician sponges of Metis in the Province of Quebec have resulted in the establishment of several genera of which a number are contained in Salter's Protospongia.

Allied to Protospongia is Dichoplectella (Pl. II., figs. 4), an object found on glossy spots of the surfaces of shales, similar to those which are marked with the cross-bars of Protospongia, and differing from it in that the spicules are seen, or appear to fork. Cyathospongia sometimes presents a somewhat similar arrangement of spicules.

Astrocladia is a modern genus to which were provisionally referred certain sponge-like forms containing monactinellid spicules, but which have not been studied in detail.

The objects defined as Monadites are minute sack-like organisms, with or without a pedicle, found in connection with sponge remains, some of which are supposed to be sponge gemmules, but others may be simple organisms of low type, whose connection with sponges has been accidental. These minute objects have been found mostly in the Etcheminian series, underlying the St. John group. Forms similar to some of these have been found in the phosphate nodules of Band *b*. Division 1 of the St. John group, and have been brought to light in sectioning these nodules.

MONADITES.

Trans. Roy. Soc. Can., vol. vii., sec. iv., p. 147, pl. vii., figs 1 *a-b*, 2 *a-b*, and fig. 3.

Size. The examples found in the phosphate nodules have a diameter of $\frac{1}{8}$ to $\frac{1}{4}$ of a mm.

Horizon and locality. Nodules of Assise 2, of Band *b*, contained these remains.

PROTOSPONGIA, Salter. Pl. II., fig. 5.

Trans. Roy. Soc. Can., vol. iii., sec. iv., p. 30, pl. v., figs 2 and 3.

Spicules of the sponges of this type have been found at several horizons of the Cambrian and Ordovician rocks of this region, viz.: Div. 1, Bands *c* and *d*, Div. 3, Band *d*. In one recently found in Band *b*, of Div. 1, the larger set of spicules is intermediate in size between those that occur in Bands *c* and *d;* it also has a secondary set of spicules (of the flesh?) of small size.

Horizon and locality. Shales of Assise 2, Band *b*, at Hanford Brook. Scarce.

ASTROCLADIA (?) ELONGATA. Pl. II., fig. 1.

Trans. Roy. Soc. Can., vol. vii., sec. iv., p. 149, pl. vii., fig. 6.

ASTROCLADIA (?) ELEGANS. Pl. II., fig. 2.

Trans. Roy. Soc. Can., vol. vii., sec. iv., p. 149, pl. vii., fig. 7.

ASTROCLADIA (?) VIRGULOIDES. Pl. II., fig. 3.

Trans. Roy. Soc. Can., vol. ii., sec. iv., p. 149, pl. vii., fig. 8 *a* to *c*.

BRACHIOPODA.

LINGULELLA, Salter.

LINGULELLA MARTINENSIS. Pl. II., figs. 6 *a* to *d*.

Trans. Roy. Soc. Can., vol. vii., sec. iv., p. 155, pl. viii., fig. 4.

Original description. " Orbicular ovate, broadly rounded in front, somewhat ventricose. No other sculpture has been observed than that of concentric and radiating striæ.

Size. Length of the ventral valve about 10 mm.; width about 8 mm.

Horizon and locality. Dark grey sandstone of Band *b.*, Assise 1, in Div. 1., St. John Group at Hanford Brook.

" This species in its deep, round valves approaches an Obolus in aspect. It is larger than any other Lingulella found with it.

Later collections enable the author to extend and improve this description. There are examples showing the surface of the shell, and others which give a clue to the internal features of the valves.

Sculpture. The shell has marked concentric ridges of growth, especially on the anterior part, and over and between these are fine concentric ridglets ; these have a beaded surface, the beads being sometimes replaced by little lamellæ.

Interior of the ventral valve. The deltidial area in this valve is markedly concave, so that the pedicel groove, as we look into the interior of the valve, is seen to start from the bottom without any shoulder such as is seen in other species. The scars of the central and lateral muscles are distinct, and extend beyond the middle of the valve. The inner surface of the edge of this valve has on each side of the area a narrow triangular groove, which appears to be a sliding articulation for the dorsal valve; further forward, on the inner edge of the valve, is another but narrower linear groove apparently for a similar use.

Interior of the dorsal valve. This exhibits a broad median ridge extending more than half the length of the valve; the ridge is divided longitudinally in the posterior half by a shallow furrow. Imprints of the cardinal and lateral muscles are visible at the back of the valve; the edges of the valve are somewhat flattened on the inside.

Varieties. Beside the type figured in the Transactions of the Royal Society of Canada, there is an obtuse form in which the ventral valve has a rounded posterior end, and the sides are more fully rounded (see Pl. II., fig. 6); in this the pedicle groove is one-fifth of the whole length of the valve. There is also an acute form in which the sides are nearly straight for two-thirds of the length of the valve, and the deltidial area is acuminate; in this the pedicle groove is two-sevenths of the length of the valve.

Horizon and locality. This species has been found to have a wider range than it was at first known to have. Besides the original location in Assise 1, where the type and the two varieties occur, the acute variety has been found in Assise 3.

In its hinge area, and to some extent in the arrangement of the muscle scars, this species resembles *Leptobolus grandis* of the horizon 3 *e* (Division 3, Band *e*), of the St. John group; it also compares with some species of Obolus, as *O* (*Botsfordia*) *pulchra.* A general resemblance exists between *L. Martinensis* and *L. Ella* of the "Middle" Cambrian of Nevada, but our species is larger, less orbicular, more rugose on the surface of the valve, and with different sculpturing of the interior of the valve.

LINGULELLA cf. GRANVILLENSIS, Walcott. Pl. II., figs. 7 *a* and *b*.

Fauna of "Upper Taconic,'' Am. Jour. Sci., vol. xxxiv., Sept. 1887.

Ovate, ventral valve rather flat, acuminate at the apex, sides curved gradually for two-thirds of the length of the valve, thence more rapidly to the front of the valve. Deltidial area small, pedicle groove one-eighth of the length of the valve.

A dorsal valve, supposed to be of this species, is deep compared with the ventral: it shows the interior which has a semicircular scar at the umbo caused by the cardinal muscle, and a broad, low, two-grooved median ridge, running two-thirds of the length of the valve. There is a partly flattened rim running around the ~~inner~~ edge of the valve, ON THE UNDER

Sculpture. The surface of the ventral valve is ornamented with very fine concentric and radiating ridges.

Size. Length of the ventral valve 8 mm.; width 5½ mm.; the dorsal valve is 7 mm. long.

Horizon and locality. Found in Assises 1 and 2; and the dorsal valve ascribed to this species is from Assise 3.

This species appears to be near Walcott's *L. granvillensis*, which it resembles in the sculpture and in its regular oval form. *L. Dawsoni*, of the Paradoxides beds has a similar form, but the striation is coarser in valves of the same size.

OBOLUS Eichwald.

Botsfordia, subgen.

Trans. Roy. Soc. Can. vol. ix., sec. iv., p. 63.

Botsfordia pulchra, Pl. iii.

Can. Rec. Sci. Jan. 1889, p. 303.

Trans. Roy. Soc. Can., vol. vii., sec. iv., p. 151, pl. viii., fig. 1, *a* to *m*, 2, *a* to *l*; vol. ix., p. 62.

Trans. Roy. Soc. Can., vol. xi., sec. iv., p. 90, pl. xvi, fig. 7, *a* to *c*.

This fine species was found in the northern basin of Cambrian rocks in southern New Brunswick, and cannot be so exactly placed as those of Hanford Brook; in the northern basin we can only thus far distinguish Assise 5 from those below, and *B. pulchra* occurs low down in the Assises 2 to 4.

Locality. Caton's Island, King's county, N. B.

The original description of this species was as follows:

"General outline nearly orbicular; the valves gently, but rather flatly and evenly arched downward from the centre all around, except that the dorsal is flatter at the back than elsewhere, and the ventral valve runs out into a short, acuminate umbo.

Dorsal valve somewhat wider than long; more strongly arched toward the front than elsewhere: somewhat elevated at each end of the hinge line.

Ventral value about as wide as long; the front evenly rounded; back produced into a short pointed beak, angle of incidence of the two sides 110° to 120°.

Sculpture of the posterior half of the valves, consisting of minute tubercles, sloping forward and arranged in rows, which arch forward across the mesian line from each lateral margin, giving the surface a cancellated appearance, like that of *Lingula* (?) *favosa* and *Kutorgina pannula*. Sculpture of the anterior part on the front and sides in the adult shell consisting of concentric lines of growth, with faint, interrupted, radiating striæ.

One of the most interesting species among the early brachiopods of the St. John group is the one named above. On account of its antiquity and because of its peculiar form in the embryonic stages, the writer now gives considerable space to the description of its characters. It is the oldest species of brachiopod belonging to the St. John group of which good material has been obtained, and the following extended account is based on this material.

The ventral valve is evenly and moderately arched, except that the sides are depressed toward the beak; the beak itself is prominent only toward the tip, and runs out horizontally from the middle of the valve.

Interior of the Dorsal Valve (Figs. 1 *i* to *m*).—The most noticeable feature of the interior of this valve is the three ridges which radiate from the hinge line toward the anterior end of the valve. The mesian ridge begins with a small tubercle near the umbo, is longer than the two lateral ridges, and divides into two outward arching forks; including these, it extends about two-fifths of the length of the valve from the hinge line; its posterior part divides the pits of the hinge line where the posterior adductor muscles were attached. The two lateral ridges extend forward from the two ends of the hinge line; and at the end of each, where it joins the hinge line, are situated the pits due to the attachment of the two branches of the cardinal muscle; outside of these two ridges are a pair of elongated semilunar scars, where the posterior adjustor muscles were attached. There is a small lanceolate ridge flatter than those described, and broader, in front of the space between the forks of the mesian ridge; this divides the anterior adductor muscles."

Additional Note. In the centre of the valve are seven small scars grouped around a short mesian ridge (fig. 1 *k*); the scar in front of the ridge is oval, and may or may not have been produced by a muscle; on each side of this scar extending diagonally backward and outward is a row of three scars of which the two first are round or nearly so, and evidently produced by muscles, while the third or posterior scar is minute and on some valves cannot be discerned, these two bands of scars, one on each side of the mesian line, form sets of muscle imprints corresponding to the two arched central scars of *O. Apollonis.* The interior of this valve is traversed by a number of ridges radiating from near the umbo to the anterior part of the valve.

"*Interior of the Ventral Valve* (Figs. 2 *h* to *l*). There is much resemblance in general aspect between the interior of the dorsal and ventral valves. The latter differs in the more elongated callus of the visceral cavity, the narrower scar of the posterior adjustor muscle, the absence of the strong lateral ridge beside this muscle, and the want of a division along the mesian line. This valve also exhibits indications of the attachment of the pedicel, and of the central adjustor muscles. The ventral valve also possesses a smaller, pointed depression in the front of the visceral cavity, which probably marks the attachment of the anterior adductor muscle. From this point, a somewhat depressed band extends to the front of the shell. There are indications that the pedicel passed through a foramen in the hinge, coming on the hinge area below the beak, but this point is not clearly determinable."

Additional Note. The ventral valve has a pair of scars in front of the hinge area due to the posterior adductors, and two pairs of lateral muscles (adjustors) extending forward at the sides one-half of the length of the valve. The central scars form a pair subtriangular in form and placed in front of the middle of the valve; the outer ends are directed backward, each scar is double and the whole corresponds to the ventral scar of *Obolus Apollonis*, only that it is wider. There are two strong ridges dividing the sliding muscles from the inner cavity of the shell, and the border of the splanchocœle is indicated by a curving line.

"*Sculpture.* The younger part of the shell is covered with minute tubercles, sloping forward, and arranged in curved rows which arch forward to the mesian line from each lateral margin of the valve, thus giving the surface a cancellated appearance; this cancellated or rasp-like surface does not cover the valve continuously, but is interrupted by arching bands of ridges concentric to the umbo. The anterior part and the outer lateral parts of the valves have the concentric ridges only, with a few, faint, broken, radiating lines, visible at intervals. The cancellated lines do not always cover so large a space on the dorsal as on the ventral valve, but the former valve shows more distinctly the radiating lines outside the visceral cavity.

Growth and Development. The growth and development of "this species as recorded in its shelly covering are very instructive. Beginning with a shell which is comparatively tumid in form and nearly semicircular in outline, it finally becomes orbicular in outline, and with valves flattened to the form of saucers.

By the varied sculpture, the outlines of the valves and the surface markings, several phases in the life of this brachiopod may be distinguished.

(1.) The first is that marked by the embryonic shell. This shell, now preserved in the umbo of the adult, shows in the markings on its surface faint indications of additions to its size, but these are hardly discernible. A remarkable feature about the embryonic shell is the form, which is entirely different from that of the adult, for it (in the dorsal valve especially) is nearly semicircular in outline, and is quite tumid when compared with the adult shell; it looks more like an Orthis or a Linnarssonia (see figs. 1*a* to *c*) than an Obolus or a Lingulella, the two genera which the adult most nearly resembles. The embryo ventral valve also differs quite as much from the adult as does the dorsal, for in its high umbo and straight hinge line it recalls species of the genera Acrotreta and Kutorgina (see figs 2*a* to *c*).

In the embryonic shell of the dorsal valve, which is narrowly semi-circular, the straight outline of the hinge was scarcely broken by the slight, rounded projection of the umbo. As viewed from above, this valve presents a hollow more or less obvious in the front of the visceral cavity. This hollow is sometimes a deeper depression, and corresponds to the outside of a tubercle or ridge within the shell, which continued throughout the life of the occupant to be a marked prominence of the interior of the valve on the mesian ridge of the shell near the hinge. The longest diameter of this hollow is about equal to one-half of the length of the embryonic shell, and in some examples it contains four little pits, which appear to mark the points of attachment of muscles (fig. 1*d*). The two lateral pits appear to answer to the anterior adductors, and the anterior pit to the anterior retractor. The anterior adjustors in this stage of growth seem to have been at the front margin of the shell, and outside of the large depression above referred to, for a series of pits can be traced on the adult shell from the margin of the embryonic shell well out toward the outer edge of the valve (fig. 1*f*). The posterior adjustors are probably indicated by a depression on each side of the umbo.

The space occupied at this time by the visceral cavity was large in proportion to the size of the shell, *and extended quite out to the margin*; and no indication of the existence of a mar-

"ginal area for the protection of a mantle and setæ can be seen. The outer posterior angles of the embryonic shell were turned upward, giving it somewhat of a saddle-shaped relief (fig. 1*d*). In some examples the shell is crossed by a raised band due to the strengthening of the hinge line during the subsequent growth of the shell (fig. 1*a*).

Already, at this very early period, we find clearly, though very minutely displayed, the rasp-like surface, which is so marked a feature of this species during the next period of its growth.

(2.) In the second phase of growth there is a decided change in the form of the shell. There was also an extension of the hinge line and a transfer outward of the muscles along that line to accommodate the growth of the animal; but although the hinge line is actually much longer than in the embryonic shell, owing to the more rapid enlargement of the sides and front, it appears to be shorter. This we may regard as the larval or næpionic stage of the shell, as by its form and features it exhibits indications of the possession of organs for the capture of food (fig. 1 *f*).

In this stage of its growth the overlapping outer layers of the shell are ridged up around the posterior angles at the ends of the hinge line of the embryonic shell, showing that now the agency of the mantle was exercised in adding the margins. In this stage of growth the shell was still quite thin, and the several stages of growth are clearly marked by the impression of the gradually enlarging previsceral depression, now less distinctly indented than in the embryonic shell; we can trace the growth of the shell by the anterior and posterior points of the previsceral depression, as well as by the two series of scars, diverging from the posterior margin that mark the periodical change in the position of the anterior adjustor muscles (figs. 1 *f* and *g*).

Owing to the thinness of the shell at this early period of growth, the frequent enlargements of the shell are shown by the defined margin of each shell layer; of these about six can be distinguished on the inner half of this zone. The surface of the shell in this part bears the rasp-like ornamentation characteristic of the species on all except the last one or two layers, where the growth is indicated only by ridges concentric to the umbo, and here there is no radulated surface. The rasp-like ornament on these shells is not unlike that on Acrothele; but in Acrothele the markings are more distinct near the margin than toward the umbo, while the reverse is the case with this shell.

This larval or næpionic part of the shell is sometimes divided "by one or two concentric lines into two parts, of which the outer is distinguished by an enlarged pattern of the radular ornamentation; and the margin of this zone has a more rounded outer margin than the inner zone, owing to the more rapid extension of the margin at the sides and front. In this outer half of the larval zone there is a more decided thickening of the shell, for the lines of growth are not so delicately marked as in the inner half, nor is the impression of the features of the interior of the shell so clearly apparent, except as regards the outlines of the visceral cavity. These features, however, may be inferred from the rounded ridges on the surface, and from the lines of scars left by the anterior adjustor muscles, which give evidence of about six stages of growth in this outer zone of the larval shell.

Outside of this zone the radular ornamentation is exchanged, on a narrow band of the shell, for concentric ridges, indicating an arrest of growth preparatory to the next phase in the life history of the individuals of this species.

The close of the larval or næpionic period is marked by the fixation of the hinge line, which no longer lengthens, and consequently the position of the posterior adductor and the proximate end of the cardinal muscle do not materially change after this.

(3) The advent of the next phase in the history of this shell, which may be called the adolescent or nealogic phase, is indicated by a return to the radular ornamentation, which now is of a still coarser pattern than previously, and is not always well preserved; in fact dorsal valves are not uncommon, and ventral valves are occasionally found, which show no radular ornament at this period, but have concentric lines only. This peculiarity, however, may be due to imperfect preservation.

This part of the valve, like the næpionic, is not unfrequently found to be divided into two zones by a few concentric lines; in the outer of these zones the radular ornament is usually very irregular.

At this period one does not find the lines of growth so distinctly marked as in the earlier period, nor the scars of the anterior adjustor and adductor muscles; but the outline of the visceral cavity, owing to the thickening of the callus formed there, stand out with great distinctness (fig. 2*e*).

The adult or ephebolic shell presents, in both valves, a nearly round contour, and on it also is rather prominently indicated the outline of the visceral cavity, which becomes proportionately narrower in the adolescent and adult stages, than at an earlier period. The marks of the muscles in the previsceral area of the shell also continue to be faintly visible on the outer portion of the shell.

This species, then, is marked by four stages of growth and development, of which the most prominent features are the following:—

(1.) *Embryonic.*—Formation of the embryonic shell.

(2.) *Larval or næpionic.*—Lengthening of the hinge line and acquisition of mantle-margins.

(3.) *Adolescent or nealogic.*—Fixation of the hinge line, otherwise as the last, except that the radular ornament becomes irregular.

(4.) *Adult or ephebolic.*—Absence of radular ornamentation on the valve, and great expansion of the mantle margin."

OBOLUS PRISTINUS, n. sp. Pl. iv., figs. 1 *a* to 1 *c*.

Shell substance calcareous (?). Valves orbicular, slightly straightened along the anterior border, and having a flattened, flange like posterior border.

The ventral valve is most elevated in the central third, and becomes flattened on the anterior slope; it is somewhat depressed medially along the raised central third of the value. The umbo is depressed and inconspicuous.

The dorsal valve is flatter than the ventral, is more depressed around the sides and has a mesian ridge within, extending about two-thirds of the length of the shell from the umbo. The umbo is quite low.

A cast of the interior of the ventral valve, probably of this species has pits on each side of the umbo for the cardinal muscles, on each side of these externally is another pair of larger muscle scars; the prints of the adductor muscles appear toward the centre of the valve.

A cast of the interior of a dorsal valve, probably of this species, has two plates extending outward along the slope of the valve on each side of the umbo; this plate is connected with a sigmoid ridge that rises upward on each side of the slope of the cast, the whole forming a crescent similar to that in Obolella and Trimerella; the prints of the lateral muscles are located by these ridges.

The prints of the adductor muscles. on each side of the mesian ridge in this valve are very far back.

Sculpture. This consists of concentric striæ, which are crossed by very close, fine, broken, radiating striæ; these cannot be seen without a very strong lens.

Size. Length 13 mm.; width 14 mm.; height of the two valves 6 or 7 mm.

Horizon and locality. Sandy layers of Assise 2 in Band *b*, at Hanford Brook. Scarce.

A description of the Protolenus Fauna would be incomplete without an account of one remarkable species, which is so constituted that it to some extent bridges the gulf between the two great orders of Brachiopods, the Articulata and Inarticulata; or rather it should be said that this form, which must be classed in the latter order, had a mechanical contrivence for hinging the valve similar to that possessed by the Articulata;* an order of which only rare individuals have been found in the Protolenus Fauna, and which is but poorly represented in the Fauna of Olenellus, but which became so vastly expanded in later ages.

TREMATOBOLUS.†

TREMATOBOLUS INSIGNIS, Matt., Pl. iv., figs. 2 *a*—*d*.

Trematobolus insignis, Matt., Can. Rec. Sci., Jan., 1893, p. 276, figs. 1 *a*—*d*.

Trans. Roy. Soc. Can., vol. xi., sec. iv., p. 88., pl. xvi., figs. 4 *a* to *d*.

Shell a meniscus, inequivalve, articulate. Valves thin, closely applied. Shell substance calcareocorneous?

Dorsal valve oblately circular, concave. At the hinge is a long, narrow socket, at right angles to the plane of the valve, fitted to receive the anterior edge of the ventral valve. The socket is interrupted in the middle by a cardinal process; this process extends into the interior of the valve, and is flanked on each side by a small, deep pit. At the back of the shell, on each side of the cardinal process, is a dental plate, and in front of it two transverse, lobed, triangular depressions, supposed to be due to the posterior adductor (cardinal) muscles. On each side of the shell, adjoining these depressions, are the scars of the adjustor muscles. There is a broad, shallow groove along the median line of the valve which would mark the part of the shell's interior traversed by the adductor muscles during the growth of the shell; this depression is divided lengthwise by a low ridge, and forks at the middle of the valve into two arched branches, which include between them a shorter depression. There are several faint, raised vascular lines (about four on each side of the median line of the valve); of these lines the

*Mr. Chas. Schuchert writes to me to say that he includes this form in Beacher's order Neotremata.

†Can. Rec. Sci., Jan., 1893, p. 276.

outer are more arched than the inner, and all radiate toward the margin of the valve.*

The ventral valve is moderately convex and oblately orbicular, with a short, blunt umbo; and has two low gradually diverging ridges, marking off a narrow triangular median area. There is a low, striated hinge area, the front edge of which is slightly toothed to fit the small pits on each side of the cardinal process of the dorsal valve. The interior of the ventral valve has a prominent ridge extending from beneath the area, half way to the front of the valve; this ridge arises from the indentation of the back of the valve by the pedicle groove; the surface of the ridge is seamed transversely by arched ridgelets, which mark the changing position of the foramen of the pedicle as the shell grew; the ridge does not quite reach the umbo, but is separated from it by a small, low boss, having a central depression, or umbilicus. In the ventral valve the position of the posterior adductors is marked by a pair of triangular scars, beginning under the outer part of the hinge; each scar shows the points of attachment of three muscular bands. The scars of the adjustor muscles, and of the lateral (anterior adductor ?) muscles run parallel to the each other along the sides of the valve, from near the hinge line; and they extend further forward than do the scars of the adjustors of the dorsal valve.

Sculpture. As we have only the interior of this shell, the surface markings of the outside are scarcely discernible; towards the front of the valve, however, they become visible under the lens, and are seen to consist of fine concentric ridges; and very fine broken, radiating striæ, visible only in a few places.

Size. Length of the dorsal valve 8 mm., width 10 mm. The ventral valve is 1 mm. longer than the dorsal.

Horizon and locality. Found by W. D. Matthew in the upper part of the second Assise of Band *b* in Division 1 ($1\, b^{2''}$) at Hanford Brook, St. Martin's.

This remarkable brachiopod is a synthetic form, showing affinities in several directions; it is thus connected chiefly with the Obolidæ, but differs from them all in the articulate connection of the valves. The arrangement of the muscles is similar to that in Obolus and Obolella, but as regards the ventral valve is modified in the direction of Siphonotreta. The position of the pedicle corresponds almost exactly with that of *Schizambon* (?) *fissus* var. *Canadensis*, Hall, of the Utica Slate,† but in our species the interior of the beak exhibits a peculiarity which

*The boss at the centre of this valve appears to be the clay plug of the foramen of the ventral valve, cemented to the dorsal valve.

† Genera Palæozoic Brachiopoda, Hall & Clark, pl. iv., fig. 33.

may indicate a habit in the young shell (or in an ancestral form of the species) different from that of the adult; this peculiarity is the existence of a small boss or callus in the umbo, which, having a central umbilicus, appears to be homologous with the boss and foramen in the umbo of such shells as Acrotreta and Linnarssonia.* Evidently the pedicle did not go out at this point in the adult shell, but the umbilicus may indicate that it did at an early stage of growth. According to Kutorga,† Siphonotreta had a mammiform swelling around the tube in the umbo.

The nature of the hinge connection too is very remarkable, and implies a mechanism similar to that of the articulate brachiopods. Compare, for instance, the dorsal valve of *Orthis* (*Orthostrophia*) *strophomenoides*, Hall,‡ or *O.* (*Dalmanella*) *testudinaria* Dal.,§ with its central ridge and cardinal process, with that of Trematobolus; in the Orthis the sockets of the dorsal valve afford a rest, similar to that furnished by the elongated pit of the corresponding valve of the former genus; in the Orthis, however, the socket is in the inner face of the valve and met the tooth only of the opposite valve, whereas in our genus the whole base of the dorsal is applied to the ventral.

The genus Barroisella of the Genessee shale shows a mechanism at the hinge similar to that of Trematobolus in the bosses on each side of the pedicle groove of the ventral valve,‖ but no such cardinal process is figured on the dorsal valve, as that which exists in the latter genus.

In the form of the median muscular imprint of the dorsal valve, Trematobolus will be seen to resemble the corresponding sculpture of the dorsal valve of Obolus, as figured by Kutorga.¶ In both genera this depression breaks up at the centre of the valve into three scars, of which the two outer ones arch around the middle one.

Another genus which shows some interesting points of resemblence to Trematobolus is Neobolus of Waagen from the Salt Range in India.** This is more especially the case with the dorsal valve, which in the latter genus possesses a callosity on the median line at the hinge, similar to the cardinal process in our genus. The depressions on each side of this callosity correspond to the scars of the posterior adductor in Trematobo-

*Op. cit. pl. iii., figs. 35, 38 and 39.

†Op. cit. pl. iv., figs. 22 and 23.

‡Op. cit. pl. v., fig. 26.

§Op. cit. pl. VB., fig. 39.

‖Op. cit. pl. ii., figs. 14 and 15. The hinge of the dorsal valve, fig. 16 (copied from Meek and Worthen), evidently does not fit the cardinal line of the ventral valve.

¶Op. Cit. p. 80, fig. 34.

**Op. Cit. p. 84, figs, 39 and 40.

lus. Further, there is a ridge corresponding to the median ridge of the latter species, and also vascular lines similar in position and direction. It is to be noted also that the position and general form of the posterior adductor and lateral adjustor scar, of the ventral valve in both genera, are the same. There is, however, a marked difference in the position of the pedicle aperture in those two genera..

Additional examples of this species were found and show the surface ornamentation, consisting of numerous concentric ridglets, some more prominent than others; the radiating lines are faint and obscure, often not discernible.

Horizon and locality. From the same horizon as those first found, viz., the middle of Assise 2.

OBOLELLA, Billings.

Obolella nitida, Ford.? Pl. ii., figs. 8 *a* and *b*.

Am. Jour. Sci., 3d Ser., vol. v., p. 213.

U. S. Geol. Surv. Bull., 30, p. 118, p. xi., fig. 2.

Among the species of Obolella this little one appears only to be known from the figure and description by S. W. Ford. We have found a few examples of a shell which does not appear to differ from this species. It would appear that Ford only had the dorsal valve, recognizable by the strong groove on the median line in the posterior half of the shell.

The dorsal in the Canadian examples is ovate-orbicular with a blunt umbo. There are impressions of the scars of the crescent that show through the shell, and traces also of the central group of muscle-scars.

Sculpture. This, as far as the surface is preserved, shows an ornamentation due to waving irregular ridges, rather than the regular cancellation described by Mr. Ford.

Size. Length of ventral valve 3½ mm.; width, 3 mm. Length and width of the dorsal valve, each 3 mm.

Horizon and locality. Sandstone of Div. 1, Band *b*. Assise 3 at Hanford Brook. Rather scarce.

LINNARSSONIA, Walcott.

Linnarssonia transversa, Hartt. Pl. v., figs. 1 *a* to *c* and 2 *a* to *c*

Obolella transversa Hartt, Acad. Geol., 2. Ed., p. 644.

Obolella transversa Walcott. U. S. Geol. Surv. Bull. 10., p. 16., pl. i., fig. 5 and 5*a*.

Trans. Roy. Soc. Can., vol. iii., sec. iv., p. 35., pl. v., fig. 11*a* to *e*.

This species is not uncommon in the upper part of Band ***b***. especially in Assise 5, whence it ranges upward through the Paradoxides beds.

ACROTRETA, Kutorga.

ACROTRETA GEMMA, Bill.?

Palæozoic Fossils, vol. i., pr. 216., fig. 201 *a* to *f*.

U. S. Geol. Surv. Bull. 30, p. 98, pl. viii, figs. 1, 1*a* and 1*b*.

A small brachiopod of the size of this species is found sparingly in the lower part of Band *b*., but owing to the coarseness of the matrix and the delicacy of the shell, the latter is greatly distorted and cannot be positively identified with this species.

Horizon and locality. Dark sandstones of Assise 1, at Hanford Brook.

The conical ventral valve and high deltidial area shows that this shell is an Acrotreta.

ACROTRETA GEMMULA. Pl. v., figs. 5 *a* to *d*.

Trans. Roy. Soc. Can., vol. xi., sec. iv., p. 87, pl. xvi., figs. 2*a* to *d*.

This pretty little shell, the smallest of its kind, originally described from the sandstones of Assise 3, has been found in Assise 2, thus extending the range downward. It has the peculiarity of a foramen opening behind the apex.

LINGULELLA (?) CŒLATA, Hall.

Orbicula cœlata Hall, Pal. N. Y., vol. i., p. 290, pl. lxxix., fig. 9*a* to *c*.

Lingulella cœlata Walcott, U. S. Geol. Surv. Bull. 30, p. 95, pl. vii., figs 1*a* to *d*.

Two examples of the ventral valve of this little shell have been found in the sandstones of Assise 1. They show the low radiating ribs and the peculiar cancellated surface of this species. One, also, has an apical depression, or minute pit in the position where the foraminal opening would be in an Acrotreta or Linnarssonia.

This species differs from *L.* (?) *inflata*, with which it occurs, in having the beak elevated, so that when seen from the side the valve is straight along the median line; whereas in *L.* (?) *inflata* it is strongly arched.

LINGULELLA ? INFLATA. Pl. v., figs. *a* and *b*.

Trans. Roy. Soc. Can., vol. iii., sec. iv., p. 33, pl. v., figs. 7 and 7*a*.

Beside the type described in the above Transactions, there is a variety of an oval form occurring with it, which presents some peculiarities of structure not observable in the first examples found.

var. OVALIS, n. var. Pl. v., figs. 4*a* to *c*.

Only the ventral valve is known. This is very tumid, rounded down at the sides, arched from beak to front, so that the highest part of the valve is about one-third from the beak; in outline the valve is ovate, with rather straight diverging sides for one-quarter of its length, thence rounded forward at the sides, and rather abruptly rounded to the front. There is a callus within the valve at the beak; this surrounds the pedicle furrow or tube, or at least encloses it at the sides and front. The foramen appears to open under the beak. There is a partial (as in *Obolella gemma*) or complete deltidial area, but in none of the specimens obtained is this area completely exposed.

Sculpture. This consists of rather strong concentric ridges, and somewhat widely set radiating ridges.

Size. Length 4 mm.; width 3 mm.

Horizon and locality. The dark gray sandstone of Assise 1, at Hanford Brook.

The rarity of dorsal valves of this variety and of the type of *L.* (?) *inflata* would perhaps indicate that they were thinner and more perishable than the ventral valves.

These little shells approach Linnarssonia more nearly in form than Lingulella, and the variety especially is so tumid that it might be taken at first glance to be an Ostracod. This species and *L.* (?) *cœlata* Hall are seemingly of the same genus and should be separated from Lingulella. They have a deltidial area elevated at an angle from the plane of the lower side of the valve, in which respect they resemble Linnarssonia and Acrotreta. It also seems probable that they possess a foramen and not a pedicle groove; this is strongly indicated in var. *ovalis* and Messrs. Hall and Clarke figure *L.* (?) *cœlata* as possessing a small pit at the apex. *L.* (?) *cœlata* is more nearly related to Acrothele and Acrotreta than to Lingulella and with *L.* (?) *inflata* belong to that group of small foraminiferous brachiopods so common in the Lower Cambrian.

ACROTHELE, Linnarsson.

ACROTHELE MATTHEWI, Hartt. Pl. v., figs. 6*a* and *b*, 7*a* and *b*, 8*a* and *b*.

Lingula Matthewi Hart. Acad. Geol., 2d Ed., p. 644, fig. 221.
Acrothele Matthewi U. S. Geol. Surv. Bull., 10, p. 15, fig. 4, 4*a*.
Trans. Roy. Soc. Can., vol. iii., sec. iv., p. 39, pl. v., figs. 15, 15*a*, 16, 16*a*, 17, 17*a*.

This is a species of wide range, and is somewhat common in the early Cambrian beds. I cannot find characters sufficient to distinguish the earlier forms from the type, which was found in Band *c*, except as varieties. Two such have been described in the Transactions above cited, but there is a third which should be referred to.

var. COSTATA, n. var. Pl. v., fig. 9.

Distinguished by six or more broad ribs, radiating toward the anterior margin. These ribs are not continuous, but are broken at certain lines of growth; they have not been observed near the umbo, but on the middle and anterior third of the shell they are well marked. This variety is more common in the shaly assises, whereas the thick, smooth shells are common in the sandstones.

Sculpture of fine wavy or broken ridges, as in the other varieties.

Horizon and locality. Found in Assises 2 and 5 of Band *b*, at Hanford Brook; in Assise 5, of Band *b* at Caton's Island, King's county; and in Band *d*, at Porter's Brook, St. John county. The shells in Assise 5 have more numerous ribs than the others.

ORTHID sp. Pl. v., fig. 10.

Remains of Articulate Brachiopods are rare in the part of the Cambrian in New Brunswick that underlies the Paradoxides beds. Only one example has been found, and that quite a small one; it is an Orthid, but is too imperfect for comparison with known species. It is a dorsal valve from which the shell has been mostly exfoliated, leaving a mould of the interior.

Horizon and locality. Dark sandstones of Assise 1, Hanford Brook.

MOLLUSCA.

HYOLITHELLUS, Billings.

HYOLITHELLUS MICANS, Bill. ?

Hyolithus micans Bill. Can. Nat., 2d Ser., vol. vi., p. 215, figs. 3*a*, *b*, p. 213.

Hyolithellus micans Walcott, U. S. Surv. Bull. 30, p. 142, pl. xiv., fig. 2*a* to *e*.

Trans. Roy. Soc. Can., vol. xi., sec. iv., p. 94.

A slender hyolithoid shell not easily distinguishable from Billings' species occurs sparingly in the hard shales of Assise 2, at Hanford Brook.

COLEOIDES, Walcott.

COLEOIDES TYPICALIS, Walc ?

U. S. Nat. Mus. Proc., vol. 12, p. 37.

Fauna of Olenellus Zone, p. 624, pl. lxxix., Figs. 6, 6*a*.

A fragment of a long, longitudinally striated fossil, which resembles Walcott's species above named, is found in one example in the beds of Assise 2 at Hanford Brook.

ORTHOTHECA, Novak.

ORTHOTHECA cf. EMMONSI. Pl. vi., fig. 1.

Hyolithes Emmonsi Ford. Am. Jour. Sci., 3d Ser., vol. ii., p. 244, figs. 3*a* to *c*.

Hyolithes communis var. *Emmonsi* Walc. U. S. Geol. Surv. Bull. 30, p. 137, pl. 14, fig. 4*a* to *b*.

Trans. Roy. Soc. Can., vol. xi., sec. iv., p. 95, pl. 16, fig. 10.

HYOLITHES, Eichwald.

HYOLITHES cf. PRINCEPS, Bill.?

Can. Nat. New Ser., vol. vi., p. 216, figs. 4*a* and *b* of p. 213.

U. S. Geol. Surv. Bull. 30, p. 135, pl. xiii., figs 5*a* and *b*.

Among the fossils collected are specimens of a large Hyolithes, which by form and size resembles the above species, but the specimens are too imperfect to make the identification sure.

Locality and horizon. Siliceous shales at the bottom of Assise 3, Hanford Brook.

HYOLITHES AMERICANUS, Bill.

Theca? triangularis, Hall, Pal. N.Y., vol. i., p. 313, pl. lxxxvii., 1, *a* to *d*.

Hyolithes Americanus, Bill. Can. Nat., 2d Ser., vol. v., p. 215, figs. 2, *a* and *b*, p. 213.

A fragment shows the prominent ventral ridge characteristic of this species.

Horizon and locality. Upper part of Assise 3 at Hanford Brook. Scarce.

HYOLITHES cf. OBTUSA, Bill.?

Salterella obtusa, Bill. Geol. Vermont, vol. ii., p. 955.

Hyolithes Billingsi, Walc. U. S. Geol. Surv. Bull. 30, p. 134, pl. xiii., figs. 1, *a* to *d*.

A small species of the form of this one occurs in fragments.

Horizon and locality. Upper part of Assise 3 at Hanford Brook.

HYOLYTHES DECIPIENS. Pl. vi., figs. 2 *a* to *d*.

Trans. Roy. Soc. Can., vol. xi., p. 96, sec. iv., pl. xvi., figs. 11, *a* to *d*.

Horizon and locality. Additional examples of this species were found in Assise 2 at Hanford Brook.

HYOLITHES GRACILIOR, n. sp. Pl. vi., figs. 3 *a* and *b*.

Tube long and slender; angle of incidence of the two edges 8°. The dorsal side is marked by lines of growth parallel to the outline of the lip, which is moderately arched. The ventral surface does not show any growth lines and is moderately convex. The proximal part of the tube is curved.

Size. Width 3 to 4½ mm.; length estimated 25 to 35 mm.

Horizon and locality. From shales at the top of Assise 3.

DIPLOTHECA.

Trans. Roy. Soc. Can., vol. iii., sec. iv., p. 52.

DIPLOTHECA HYATTIANA. Pl. vi., figs. 5*a* and *b*.

Trans. Roy. Soc. Can., vol. iii., sec. iv., p. 52, pl. vi., fig 4, 4 *a*. Found in Assise 3 at Hanford Brook.

DIPLOTHECA ACADICA, var. CRASSA. Pl. vi., fig. 4.

Trans. Roy. Soc. Can., vol. iii., sec. iv., p. 55.
Found at the same horizon as the preceding.

PELAGIELLA, n. gen.

In a paper written for the Royal Society of Canada in 1892 the author described a singular spiral shell from Band *b* as of the genus Cyrtolites Conrad (printed Cyrtolithes), supposing that the whorl was symmetrical: the more abundant material obtained by Messrs. van Ingen and Matthew show that it is never quite symmetrical, and that in this and other respects the reference to Cyrtolites will not hold; the author therefore proposes the above name, with the following description: Shell a discoid spiral of few whorls, flattened, lenticular, whorls somewhat angulated at the outer edge, slightly flattened on the upper side, somewhat tumid on the lower. Lips of the aperture, both upper and lower, arched forward in the middle. Spire sunken. The peculiar lip appears to indicate that this animal was a free swimmer, and it is supposed to have been a Heteropod. It is gigantic compared with most of the shells of this sub-class, but there are some like the Violet-snail that are larger. Maclurea, Bellerophon &c., which also have been included in the Heteropods, are much larger.

PELAGIELLA ATLANTOIDES. Pl vi., figs. 6 *a* to *c*.

Cyrtolithes atlantoides. Trans. Roy. Soc. Can., vol. xi., sec. iv., p. 94, pl. xvi., figs. 8*a* and *b*.

There is a good deal of variation in the form of this shell, some being more flattened on the upper side than others. The spire is always sunken below the level of the last whorl, and the species is easily recognized by the peculiar constricted band around the last whorl, next the lip of the shell; the more perfect shells, lately found, show that the "shallow curving furrow near the inner edge of the whorl" is the impression left by the ventral portion of this band on the growing shell. The low ridge traversing the middle of the whorl on its upper side corresponds to the projecting almost angulated portion of the lip. The umbilicus is not well shown in any of the specimens. There is no notch or slit at the projecting part of the last whorl, but the depressed band at the back of the lip is pinched in a little on each side at this point. As there are no depressed rings on the shell, it appears that this constricted band was formed only on the adult shell.

The species seems to be that of a free swimmer, and the form of the orifice corresponds to that of a Heteropod or a Nautilus, rather than that of a true Gasteropod.

Size. Somewhat larger examples are known than those first described. Length across the whorls 9 mm.; width of the last whorl 6 mm.

Horizon and locality. The range has been extended downward from the upper part of Assise 3, where it was first found, to Assise 2. It is most abundant at the latter horizon, but infrequent in both.

VOLBORTHELLA, Schmidt.

Trans. Roy. Soc. Can., vol. vii., sec. iv., p. 156.

VOLBORTHELLA TENUIS, Schmidt. Pl. vi., figs. 7 *a* and *b*.

Trans. Roy. Soc. Can., vol. vii., sec. iv., p. 156, pl. viii., figs. 5, *a* and *b*.

The fossils from Band *b*, in the northern basin of Cambrian rocks are authentic examples of this species; this would appear from typical examples of the Russian species sent me by Dr. F. Schmidt, with which the King's county fossils agree. It is not so certain that the tubular shells from the Etcheminian series at Hanford Brook are correctly referred here.

Horizon and locality. Olive grey shales (of Assize 5?) in Band *b*, at Belyea's Landing, King's county, N. B.

OSTRACODA.

HIPPONICHARION.*

Trans. Roy. Soc. Can. 1885, vol. iii., p. 64.

As this genus is one which is readily recognized, it affords a useful landmark in the Lower Cambrian, and the original description is quoted here: "Valves wide, semi-elliptical, subequilateral; outer area of the valve, except on the side next the hinge; strongly elevated into prominent marginal ridges; central area, including the upper side of the valve, greatly depressed, and having an inconspicuous central ridge near the hinge-line; valves nearly equal.

HIPPONICHARION EOS Pl. vii., figs. 1 *a* and *c*.

Trans. Roy. Soc. Can., vol. iii., p. 64, pl. vi., figs. 19, 19 *a* and *b*.

No examples of this species were found in the material examined from Assises 2 and 3, and its range is probably confined to Assise 1.

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* In allusion to its resemblance to the print of a horse's hoof.

HIPPONICHARION CAVATUM Pl. vii., figs. 2 *a* and *b*.

Trans. Roy. Soc. Can., vol. xi., p. 99, pl. xvii., figs. 3 *a* and *b*.

This species also appears to be confined to Assise 1. Hipponicharion in all its species looks like the head shield of Microdiscus, but it is never bilaterally symmetrical as the head shield of a trilobite would be.

HIPPONICHARION MINUS Pl. vii., figs. 3 *a* and *b*.

Trans. Roy. Soc. Can., vol. xi., p. 99, pl. xvii., figs. 4 *a* and *b*.

Several specimens of this species were found in the upper part of Assise 3, at Hanford Brook.

BEYRICHONA.*

Trans. Roy. Soc. Can., vol. iii., p. 65

The original description of this genus was as follows: "Valves nearly or quite as wide as long and wider in front (behind) than behind (in front); they have a rudely semi-circular flattened area, extending not more than half way from the hinge-line; the rest of the valve is convex, and most elevated near the middle; the flattened area has several depressions which are not very prominent (*i. e.*, conspicuous).

"There is no median ridge, properly so-called, on the valve of this genus, but there are two very small oblique ridges, close to the hinge line of which the anterior (posterior) may be taken to represent the median ridge; the posterior (anterior) ridglet becomes confluent with the inner termination of the anterior ridge.

"The protuberances on the surface of the valves are not so marked in this genus as in Hipponicharion and Beyrichia."

Further discovery shows that this description in one respect is incorrect, and the words in brackets should be used to correct it. The species first descr.bed were so much alike at the two ends that it was difficult to determine which was the anterior; the present view is that the wider end is the posterior end of the valve, but it is associated with the unusual condition that this is the thin end; the widest space within the valves is at the anterior end, and here also are situated the highest tubercle and the deepest pit. This remark applies to all the species, but with more force to those about to be described than to the ones on which the original diagnosis was based.

I incline to the belief that the two species which Mr. Walcott has described and referred to Aristozoe of Barrande are of this genus, and especially his *A. rotundata*. Both have that high,

* Augmentative of Beyrichia.

somewhat oblique form of valve which is so characteristic of Beyrichona, and if one glances over plate 23 of Barrande's supplement it will be apparent how different is Aristozoe in its general aspect from these Lower Cambrian species. H. Woodward, T. R. Jones and O. Novák all have referred Aristozoe to the Phyllocarida; but Beyrichona is certainly an Ostracod and the two species from the Olenellus zone agree in size better with the Ostracoda than the Phyllocarida. *A. bisulcata* of Barrande, which Mr. Walcott compares with *A. rotundata*, has protuberances where the latter species has a sulcus or hollow.

BEYRICHONA PAPILIO Pl. vii., figs. 4 *a* to *c*.

Trans. Roy. Soc. Can., vol. iii., p. 65, pl. vi., figs. 20, 20 *a* and *b*. (Reverse the description as regards the anterior and posterior ends.)

This should have been reported from Assise 4, not Assise 2.

BEYRICHONA TINEA Pl. vii., figs. 6 *a* to *c*.

Trans. Roy. Soc. Can., vol. iii., p. 66, pl. vi., figs. 21, 21 *a* and *b*.

(Reverse the description of the two ends as in *B papilio.*)

This was found together with the preceding and should also be reported from Assise 4.

BEYRICHONA PLANATA n. sp. Pl. vii., fig. 7.

Obliquely semi-circular, somewhat longer than high, moderately convex, most so in the middle; from the raised centre of the valve an arched ridge curves forward to the ocular tubercle, near the hinge line; in the opposite direction a low inconspicuous ridge extends backward to the posterior upper corner of the valve; behind the ocular tubercle is a broad furrow or pit that extends backward half of the length of the cardinal line, becoming narrower in its posterior half; on the anterior side of the valve there is a flattened band that extends to the lower margin, where a narrow obscure furrow appears, and extends thence to the posterior corner of the valve. The anterior half of the valve is somewhat tumid, and the posterior is flattened out toward the posterior margin so that the two valves together form there a sharp knife-like edge.

Sculpture. The surface is uneven, minutely punctate and shining, like *B tinea*, from which its differs in its greater proportionate length, greater size, shallower cardinal furrows, flatter posterior border, and the obscureness of the border fold.

Size. Length 5 mm.; height $4\frac{1}{4}$ mm.

Horizon and locality. Olive green shales of Assise 2 at Hanford Brook. This is the common species of Assise 2.

Varieties. Among the examples from Assise 2 are young shells which by their three-cornered shape resemble *B. triangula* (see below); these may be distinguished from that species by the larger and more depressed lunule near the cardinal area, and by the characteristic sculpture. Other forms by their more elevated posterior half and shorter valves approach *B. tinea*, but a comparison with the type of that species serves to separate them.

This species (*B. planata*), is of interest as the companion of the Foraminifera described on a previous page; where they are most abundant *B. planata* is the prevailing Ostracod; the association may indicate that this type of Ostracoda lived in the open sea and was not so dependent on shore conditions as some others.

BEYRICHONA TRIANGULA n. sp. Pl. vii., fig. 5.

Subtriangular, rather flat with an abrupt anterior slope. The valve is bordered by a narrow marginal rim. Posterior margin nearly straight, anterior moderately curved, the lower corner of the valve bluntly rounded. Ocular ridge prominent.

Scupture. This species has a fine granulation like *B. papilio.*

Size. Length $3\frac{1}{2}$ mm.; height 3 mm.

Horizon and locality. Occasionally in the shales of Assise 2, but more frequent in the sandstones of Assise 3. Scarce.

This species differs from the others except *B. papilio* in its triangular form and the obsolescence of the flattened lunate area at the upper side of the valve; from *B. papilio* it differs in being less abruptly pointed below, in having a marginal fold, and in the absence of the sharp thread-like posterior cardinal ridge possessed by that species.

BEYRICHONA OVATA n. sp. Pl. vii., fig. 8.

Transversely ovate, hinge-line short, not much more than half of the length of the valve; valve broadest one-quarter from the top, thence gradually tapering to an obtuse point; the valve is bordered by a narrow but distinct marginal fold; the ocular ridge is rather broad, the muscular depression subcentral, near the hinge-line, but not extending to it.

Sculpture. Obscure, the surface where it is preserved is minute granulate.

Size. Length $2\frac{1}{2}$ mm.; height 4 mm.

Horizon and locality. Olive grey shales of Assise 2, at Hanford Brook. Rare.

BEYRICHONA ROTUNDATA, n. sp. Pl. vii., fig. 9.

Broadly semi-circular. Flattened area of the valve extending halfway across from the hinge-line; valve more elevated in front than behind, having a narrow and obscure marginal fold behind, but none visible on the front half.

Sculpture. Surface as in *B. planata.*

Size. Length 5 mm.; height 3½ mm.

Horizon and locality. Shales of Assise 2 at Hanford Brook. Scarce.

Compare this species with Walcott's *Aristozoe rotundata* from the Lower Cambrian of Washington county, N. Y. The general form is similar, but it differs in the narrower marginal fold and smaller size.

APARCHITES, T. Rupert Jones.

APARCHITES SECUNDA, n. sp. Pl. vii., figs. 11 *a* and *b*.

Oval, tumid, hinge-line more than half of the length of the valve; near the anterior end is a slight swelling where the eye-spot might be; there is a faint thread-like ridge along the cardinal line, where the margin of the valve is straight; the ventral border is rolled in on each side and no marginal fold is visible.

Sculpture. The surface is minutely rugose.

Size. Length 4 mm.; width 2½ mm.

Horizon and locality. Sandstones of the upper part of Assise 3, at Hanford Brook.

PRIMITIA, T. Rupert Jones.

PRIMITIA AURORA Pl. viii., figs. 1 *a* to *c*.

Trans. Roy. Soc. Can., vol. xi., p. 98, pl. xvii., fig. 5 *a* to *c*.

This species was found in the dark gray sandstones of Assise 1, some years ago.

PRIMITIA OCULATA, n. sp. Pl. viii., figs. 2 *a* and *b*.

Obliquely oval, tumid, straight on the hinge-line, which is about two-thirds of the length of the valve; there is a prominent ocular tubercle near the anterior end, and behind the tubercle a shallow groove. Two depressions are noticeable on the posterior end of the value.

Sculpture. The test is distinctly pitted.

Size. Length 3 mm.; height 2 mm.

Horizon and locality. Sandstones of the upper part of Assise 3. Rare.

PRIMITIA (?) FUSIFORMIS, n. sp. Pl. viii., figs. 3 *a* and *b*.

Valve spindle-shaped, bluntly pointed in front, obtusely rounded behind, tumid. It has a shallow furrow on the anterior third, extending from the back halfway across; behind the furrow at the median line of the valve is a low tubercle.

Sculpture. The surface of the test is finely granulated; at the posterior end of the valve the pits are arranged lengthwise of the valve, and give that end a striated appearance.

Size. Length 7 mm.; height 3 mm.

Horizon and locality. Sandstone of the upper part of Assise 3, at Hanford Brook. Rare.

SCHMIDTELLA, Ulrich.

SCHMIDTELLA CAMBRICA, n. sp. Pl. vii., figs. 10 *a* and *b*.

Valves ovately circular, somewhat wider than long, quite tumid, with the greatest convexity towards the hinge-line. There is a very narrow fold at the anterior (?) and on the ventral margin. Hinge-line about half of the length of the valve.

Sculpture. Surface of the valves minutely pitted.

Size. Length and breadth each $2\frac{1}{2}$ mm.

Horizon and locality. Sandstone of the upper part of Assise 3, at Hanford Brook. Scarce.

LEPERDITIA, Rouault.

The following species are referred provisionally to Leperditia; unfortunately the material is defective, and in no instance have both valves been preserved in contact so that one could see whether they overlap and are unequal; it is on account of the size and general form of these crustaceans that they are thought to be referable to the genus above named, or one closely allied.

LEPERDITIA (?) VENTRICOSA Pl. viii., figs. 5 *a* to *d*.

Trans. Roy. Soc. Can., vol. vii., p. 159, pl. vii., figs. 12 *a* to *d*.

Found in the dark gray sandstones of Assise 1, at Hanford Brook.

LEPERDITIA (?) STEADI Pl. viii,, figs. 7 *a* to *c*.

Trans. Roy. Soc. Can., vol. vii., p. 160, pl. vii., figs. 13 *a* to *c*.

Found with the preceding. Prof. T. R. Jones in a letter to the writer suggests that these two species may be of the genus Isochilina.

LEPERDITIA (?) MINOR, n. sp., Pl., viii., figs. 4 *a* and *b*.

Test broadly oval, with a straight hinge-line; moderately convex; the two ends of the valve make obtuse angles with the hinge-line. There is a shallow furrow extending from near the anterior end of the valve toward its middle; at the end of the furrow is a small tuberculous elevation.

Sculpture. This consists of deep, rather distinct pits as in *L. Steadi*, which this species resembles in form, but it is much smaller.

Size. Length $2\frac{1}{2}$ mm.; height of the valve nearly as great.

Horizon and locality. Sandstones at the top of Assise 3. Scarce.

LEPERDITIA (?) PRIMÆVA, n. sp., Pl., viii., figs. 6 *a* and *b*.

Only the right valve is known; this is oval and has a straight hinge-line two-thirds of the length of the test. The valve is somewhat pointed at the hinge in front, and rounded from the hinge behind. A scar in the centre of the valve where the test is broken away may indicate the place of the adductor muscle.

Sculpture. A portion of the carapace preserved shows a very fine punctation.

Size. Length $5\frac{1}{2}$ mm.; width 4 mm.

Horizon and locality. Sandstones of Assise 3 (lower part), Hanford Brook. Rare.

PHYLLOPODA?

LEPIDITTA.*

Trans. Roy. Soc. Can., vol. iii., p. 61.

LEPIDITTA SIGILLATA, Pl. viii., fig. 8.

Trans. Roy. Soc. Cans., vol. xi., p. 98, pl. xvii., fig. 1.
This species was found in the Sandstones of Assise 3.

TRILOBITA.

PROTAGRAULOS n. gen.

A small trilobite related to Agraulos and Holocephalina by its general form, occurs sparingly in sandstone layers of Band *b*.

Glabella depressed to the level of the cheeks, scarcely traceable except at the posterior end. Cheeks slightly arched down at the front and sides. Eyelobes long. Anterior extensions of the facial sutures approximated.

* = Little scale.

This form differs from Agraulos in the narrow front to the middle piece of the cephalic shield and in the long eyelobes, as well as the oblique direction of the facial suture, taken as a whole. From Holocephalina it differs in the larger free cheeks, the narrow space between the sutures in front, and by the length and position of the eyelobe. From both genera it differs by its long glabella, which, though but faintly indicated on the surface of the shield, can be traced.

PROTAGRAULOS PRISCUS, n. sp., Pl. ix., fig. 1.

Only the middle part of the head shield is known; this is rather flat, and is moderately arched down at the sides and front. Front margin with a faint, narrow rim; the front area on the axial line is half of the width of the glabella at its widest part; the middle piece of the head is narrow between the sutures in front. Glabella one-fifth longer than wide, obscurely marked off from the cheeks, except in the posterior half; dorsal furrow scarcely visible except near the back of the shield. Occipital ring more than twice as long as wide, separated from the glabella by a faint furrow. Fixed cheeks long, narrow, moderately arched; eyelobes scarcely raised above the surface of the cheeks, nearly as long as the glabella.

Sculpture. The surface appears to be minutely punctate, and has small scattered tubercles.

Size. Length of the middle piece of the head 10 mm.; width in front 6 mm.; at the eyelobes 12 mm.

Horizon and locality. Sandstones of the middle part of Assise 3 at Hanford Brook.

A few heads of the trilobite have been found; the form is such that imperfect examples might easily be mistaken for the pygidium of a larger trilobite, but the depression in front of the eyelobes, though shallow, indicates a head shield. This depression is continuous with the dorsal furrow, turns outward and downward to the corner in front of the eyelobe, and by throwing the front area of the shield in connection with the glabella gives to the axial ridge of the shield a pseudo-club-shaped glabella like that which is found in the embryonic tests of Conocoryphe, Liostracus and Ptychoparia.

ELLIPSOCEPHALUS, Zenker.

Trans. Roy. Soc. Can., vol. xi., p. 103.

ELLIPSOCEPHALUS GALEATUS Pl. ix., figs. 4 *a* to *g*.

Trans. Roy. Soc. Can., vol. xi., p. 103., pl. xvii., figs 7 *a* to *e*.

The figure of a thoracic segment given with this species, does not correctly represent the actual segment. The ring when articulated with adjoining ones shows no furrow; and the pleural groove is shallower than represented in the figures. The number of segments in the thorax, given as eleven, may not be exactly that number.

This species is from the sandstones of Assise 3.

ELLIPSOCEPHALUS GRANDIS Pl. ix., figs. 3 *a* to *c*.

Trans. Roy. Soc. Can., vol. xi., p. 105, pl. xvii., figs 6 *a* to *c*.

This is the largest species of its genus known from the Lower Cambrian; it has a short genal spine, and is from the upper part of Assise 2.

ELLIPSOCEPHALUS sp.

Trans. Roy. Soc. Can., vol. v., p. 129, pl. ii., figs 8 *a* to *c*.

This, the oldest known species of Ellipsocephalus, is from the dark gray sandstones of Assise 1.

AVALONIA Walcott.

Under the name of Avalonia, Mr. Walcott has described a small trilobite which is evidently related to Ellipsocephalus, but which has differences that make it desirable to separate it from that genus. The chief differences are the greater proportionate size of the glabella, the plaited anterior margin, the weak posterior margin and the furrow around the fixed cheek. A species with these characters occurs with the Protolenus Fauna.

AVALONIA ACADICA n. sp. Pl. ix., fig. 5.

Head shield semi-circular, rounded down at the sides, and also at the front and back. Dorsal suture directly forward to the anterior margin and backward, behind the eyelobe, to the posterior margin.

Anterior margin of the middle piece of the head shield broad, plaited in front. Glabella cylindro-conical, slightly narrower in front than at the back; three very faintly marked furrows are visible. The occipital furrow is distinct and the ring broad and crowned by a low tubercle. The fixed cheeks are rather tumid, and at the anterior corner of the glabella, crossed by a shallow groove that extends outward to the dorsal suture; there is a very faint ocular fillet on the raised part of the fixed cheek. The posterior margin and fold are narrow, and the latter is geniculated at the middle.

The movable cheek is narrow, arched inward at the end, and apparently without spine.

Sculpture. The surface of the test is smooth and shining, but under a lens appears to be minutely punctured. At the back of the fixed cheeks are faintly marked, radiating and anastomosing raised lines.

Size. Length of the head shield 6 mm.; width 8 mm.

Horizon and locality. Sandstones of Assise 3 at Hanford Brook. Rare.

This species appears to belong to Walcott's genus Avalonia by its form, size and surface ornamentation. There is a groove around the front of the fixed cheek, such as Walcott has described for *Avalonia manuelensis;* but in our species the front of this groove does not take the place of the ocular fillet, which is further back on the cheek. The heavy occipital ring is a conspicuous difference from the Newfoundland species.

MICMACCA n. gen.

Under this head the author proposes to describe a group of trilobites with large, rather prominent, cylindrical glabella, which extends almost to the front of the shield; and with continuous eyelobes, and a short, direct posterior extension of the dorsal suture.

In the narrow front area of the head shield and the large glabella, they are like Zacanthoides of Walcott, but they have not the long outward posterior extension of the dorsal suture; hence the pleuræ must have been essentially different.

In the long eyelobes and the short posterior extension of the suture they resemble Ellipsocephalus, but they lack the comparatively wide front area of the middle piece of the head shield of that genus, and its smooth glabella, expanded in front; they are all trilobites of larger size than any true Ellipsocephalus. The genus is named for a tribe of Acadian aborigenes.

Micmacca Matthevi n. sp. Pl. x., figs. 1 *a* and *b*.

Middle piece of the head subquadrate. Front margin with a narrow flat fold; front area greatly narrowed in front of the glabella. Glabella large, cylindrical, slightly enlarged at the front, having three pairs of furrows, scarcely perceptible. Occipital ring broad, rounded forward at the back, divided from the glabella by a distinct furrow; it bears a small tubercle on the axial line. The fixed cheeks are tumid, depressed before and behind; at the inner posterior corner it extends behind the occipital furrow, and thence is arched forward to the eyelobe;

the eyelobes are opposite the posterior two-thirds of the glabella, narrow and moderately arched. Dorsal suture, except at the eyelobe, nearly parallel to the side of the glabella.

Sculpture. This consists of tubercles which on some parts of the shield are arranged in sub-parallel rows (*e. g.*, the back of the glabella and the front of the fixed cheeks).

Size. Length of the head shield 21 mm.; width between the dorsal sutures, at the front 21 mm.; at the eyelobes 26 mm.

Horizon and locality. In the purple-streaked sandstones of Assise 3, Hanford Brook. Scarce.

This species is named for the discoverer, W. D. Matthew.

MICMACCA VAN-INGENI n. sp. Pl. xi., figs. 1 *a* and *b*.

This species differs from the preceding in the following respects; the glabella is more prominent and narrower and has deeper furrows, and the occipital furrow is also more distinct. The occipital ring bears a strong spine, projecting upward and backward; the width of the spine and ring together is equal to that of the fixed cheek.

Detached pleura which have a prominent spine on the posterior ridge of the ring, probably belong to this species.

Sculpture. This consists of distinct granulations covering the whole surface of the test.

Size. Length from the front of the glabella to the tip of the occipital spine 20 mm.; width between the eyelobes 22 mm.

Horizon and locality. Sandstones of Assise 3, at Hanford Brook. Scarce.

Named for the collector, Mr. Gilbert van Ingen.

This species is allied to *Zacanthoides spinosus* Walc., of the Eureka district in Nevada,* by the form and size of the glabella, and the large occipital spine; it however has wider fixed cheeks, and no trace of the long posterior extension of the dorsal suture, necessary to a Zacanthoides. *Z. spinosus* is stated to have a wide range, even up into the Potsdam horizon (Upper Cambrian); the lower horizon is not much above the Olenellus Zone; possibly there are two species, of which only the later one has the extended posterior suture; the earlier one only is shown to have the heavy occipital spine.

MICMACCA RECURVA n. sp., Pl. x., figs. 3 *a* to *c*.

Form of the head shield semi-circular. Anterior margin with a narrow, upturned rim. Glabella quadrate, rounded in front, slightly wider opposite the eyelobes than elsewhere, faintly im-

* U. S. Geol. Surv. Bul., 30, p. 184, pl. xxv. figs. 6 and 6 *a*.

pressed with two, somewhat oblique furrows; there is a small obscure tubercle on the edge of the glabella opposite the ocular fillet; the glabella is flatly arched sidewise, bent down behind, and is bounded by a distinct dorsal furrow. The fixed cheek is rather flat, arched down at the side in front, and also arched downward at the back; it bears a thick ocular fillet, which terminates in a distinct swelling at the dorsal furrow; it has a well defined though narrow groove, which descends to the posterior marginal furrow inside of the eyelobe; the eyelobe is continuous to the posterior marginal furrow. The occipital ring is depressed below the glabella, and is narrow. The posterior fold and furrow also are weak and narrow. The dorsal suture runs forward to the frontal limb, parallel to the axis of the shield, and backward behind the eyelobe direct to the posterior margin.

A movable cheek, which accompanies the centre piece of the head of the species, is narrow, moderately arched, and rounded at the genal angle.

Sculpture. The surface is minutely tuberculate.

Size. Length of the head-shield 18 mm.; width at the front, between the sutures 16 mm., at the eyelobes 23 mm.

Horizon and locality. Sandstones at the top of Assise 3. Scarce.

This species is distinguished from the others by its upturned anterior marginal fold, and by the sharp furrow along the inside of the eyelobe. In this and in the tubercle at the side of the glabella it resembles genus Avalonia, Walcott. The glabella is broader and flatter than that of the two preceding species.

This species appears to have many points in common with *Zacanthoides levis* found in company with *Olenellus Gilberti* at Highland Range, Nevada *; the form of the glabella, the upturned front margin of the shield, and the sweep of the ocular fillet and eyelobe are similar; but our species appears to have a direct posterior extension of the suture, which would exclude it from Zacanthoides. Mr. Walcott compares *Z. levis* with Billings' *Bathyurellus abruptus* only known by a small head from northern Newfoundland †; this species, however, is referred by Mr. Billings to the Quebec Group (Ordovician), and so must be of much later date than the other two species above named.

MICMACCA (?) PLANA n. sp. Pl. xi., figs. 2 *a* and 3 *b*.

Middle piece of the head-shield subquadrate, depressed, except the glabella, which is only moderately elevated. Front

* U. S. Geol. Surv., Bull. 30, p. 187.

† Palæoz. Foss., vol. i., p. 263.

margin moderately arched, having a narrow indistinct fold. Glabella large, cylindro-conical, flattened on the sides, descending gradually at the front, and bordered by a distinct, but faintly impressed dorsal furrow. The glabella has two pairs of furrows, which are set well forward, the posterior pair oblique and arched backward, the anterior pair faint, at first transverse, then arching backward. Occipital ring broad, marked off from the glabella by a faint, continuous furrow; the ring is arched forward at the side, bears a slight, comma-shaped elevation on each side, and carries as short, acute spine at the back. The fixed cheek is subtriangular; within the eyelobe it is about half as wide as the glabella; the ocular fillet is well marked and is directed backward; cheek nearly flat, concave near the eyelobe, which is long and moderately arched.

Sculpture. This consists of fine, closely set granulations, just visible to the unassisted eye.

Size. Length of the head-shield 17 mm.; width between the dorsal sutures, at the front 20 mm.; at the eyelobes about 24 mm.

Horizon and locality. Purplish gray sandstone of Assise 3, at Hanford Brook. Scarce. Collected by W. D. Matthew, 1892.

This species differs so much from the two preceding that it is placed in this genus only provisionally.

Among the described species of the Cambrian, *Zacantheides typicalis*, Walcott, comes nearest this. As the posterior dorsal suture of our species is not known, a satisfactory comparison cannot be made; it certainly has not the peculiar sculpture found on the cheeks of that species, and the ridge on the side of the occipital ring in our species, is not the round tubercle represented on *Z. typicalis;* but the sculpture of radiating lines is invisible on the outer surface of the test in species which have it well marked on the inner surface. Possibly there is a genetic connection.

It seems desirable to quote here for the benefit of those who may not have access to earlier publications on the St. John Group faunas the description of the genus of trilobites which is most characteristic of the fauna of Band *b*.

PROTOLENUS Matthew.

Nat. Hist. Soc. of N. B. Bull., 10, p. 34.

Trans. Roy. Soc. Can., vol. xi., pt. iv., p. 100.

Head shield semi-circular, moderately vaulted, outer part of the cheek movable, prolonged at the genal angle into a spine.

Middle piece of the head more or less quadrate. Anterior margin wide, having a narrow distinct fold at the rim. Glabella conical or cylindro-conical, prominent, marked by furrows on the sides, and distinct from the occipital ring. Fixed cheeks of variable width, bordered by a long, continuous or nearly continuous eyelobe. Extension of the dorsal suture both in front of and behind the eye, more or less direct to the margin.

Movable cheek regularly curved, area wider than the distinct fold, spine usually long.

Thorax of many joints, pleuræ grooved for part of their length, more or less geniculate, curved backward in the distal part, extended into points or spines.

Pygidium in the Canadian species unknown (small?) in the Sardinian species like that of Olenus or Paradoxides.

PROTOLENUS PARADOXOIDES Pl. x., figs. 3 *a* and *b*.

Nat. Hist. Soc. N. Bruns'k, Bull. 10, p. 36, fig. 2.

Trans. Roy. Soc. Can., vol. xi., p. 101, pl. xvii., fig. 10 *a* and *b*.

The thorax in this species is narrow, owing to the shortness of the pleuræ; the ring is prominent and has a strong furrow, and the pleura is flat and carries a diagonal groove, which terminates at the root of the spine; the spine is short and bent abruptly backward.

Part of a hypostome has been preserved; it is dome-like in form, and the interior has numerous arched thread-like furrows.

PROTOLENUS BI-TUBERCULATUS n. sp. Pl. x., figs. 4 *a* to *c*.

Only the middle piece of the head shield is known. The front margin is broken. leaving only the area, which is narrow. Glabella cylindro-conical, moderately raised, enclosed by a distinct dorsal furrow, which is but faintly impressed at the front; the glabella has three pairs of oblique furrows, the two posterior sharply impressed, and connected over the axis by a shallow depression; the posterior lobe of the glabella bears a pair of small oval tubercles near the front, and about midway of each half. The occipital ring is only partly preserved, and is separated from the glabella by a sharp furrow, directly transverse. The fixed cheek is flat and somewhat concave along the middle; it has a small, low, longitudinal ridge near the posterior inner corner, and a tubercle-like ocular fillet; the eyelobe is mostly broken away, but the form of the cheek indicates that it was continuous.

The thorax is narrow. A portion of one, supposed to be of this species, found in the lower layer of Assise 3, shows a strong grooved ring, having a pair of tubercles in the groove; the pleuræ are partly preserved.

Horizon and locality. The head-shield is from the upper part of Assise 3 at Hanford Brook.

BERGERONIA n. subgen.

A better knowledge of the species *Protolenus elegans* makes it necessary to separate it from *Protolenus paradoxoides* by something more than a specific designation. The segment of the thorax of *P. elegans*, figured in the author's paper, read before the Royal Society of Canada in 1893, was found in slaty rock, and had been flattened by pressure; for this reason it did not show the strong geniculation, which the pleuræ in their natural form possess. A comparison of the pleural parts of the two species named above, show radical differences, and although the glabellas are similar, it seems desirable to mark the difference in other respects by a subgeneric name. *P. elegans* in the strongly grooved and geniculate pleuræ, resembles Ptychoparia (and Solenopleura but for the apical spines), while *P. paradoxoides* has the flat pleura, with diagonal furrow, characteristic of the Olenidæ.

To the species *elegans*, which would thus become the type of a subgenus, should be added one which has been doubtfully ranged under Agraulos and Ellipsocephalus, but which now by its thorax, and the general contour of the head-shield, is seen to be congeneric with *P. elegans*; this is *Ellipsocephalus* (?) *articephalus.*

In dividing off a new genus or sub-genus, it is customary to retain the species first described as the type of the old genus; but in this case it would not be advisable to do so, because the second represents best the conception of the genus. *P. elegans* was described first, because the material for the elucidation of this species was most complete. To some naturalists Bergeronia will seem only a subgenus of Protolenus; whether it be considered a genus or subgenus will depend upon the comparative importance assigned to the thorax, as contrasted with the glabella. Barrande, Salter and other writers on the trilobites, have considered the course of the dorsal suture, and the form of the pleura, its groove and facet, of great importance in determining genera; the determination of the standing of Bergeronia will depend upon whether we assign the greater value to the pleural features, or to the form and relation of the glabella.

It was probably because of the resemblance borne by the thorax of *S ? Howleyi* of the Lower Cambrian of Newfoundland to that of a Solenopleura that Mr. Walcott ranged that species provisionally under this genus; but the author's studies of the embryonic forms of Solenopleura and other Ptychoparida show that this species can hardly be included in that genus. For in Solenopleura the eyelobe, even in the youngest forms in which it can be seen, is short; the process of development of the eyelobe in this family is not a shortening of that protuberance, but a gradual withdrawal of it from the margin of the head toward the glabella; a Solenopleura then could never have had the eyelobe of the form of that of *S? Howleyi*.*

And as regards *B. elegans*, it is not related to the Ptychoparida, notwithstanding a certain resemblance in the pleura. The course of its dorsal suture is similar to that of the early forms of Paradoxides, and the movable cheek is of the type of the cheek of that genus, but its glabella and pleuræ separate it both from that genus and from Olenellus. It stands apart as one of the ancestral types of this ancient fauna.

BERGERONIA ELEGANS W. D. Matthew MSS., Pl. xi., figs. 3 *a* to *e*.

Protolenus elegans, Nat. Hist. Soc. N. Bruns'k Bull. 10., p. 25, fig. 1.

Protolenus elegans, Trans. Roy. Soc. Can., vol. xi., p. 100, pl. xvii., figs. 9*a* to *d*.

Examples of this species taken from the shales, are larger than those found in the phosphate nodules; among those collected from the shales last summer was one having a head-shield 40 mm. long; this is double the length given in the original description of the species; the width at the anterior margin between the sutures is about the same (40 mm.), and at the posterior end 52 mm.; the specimen is a good deal flattened in the shale.

Examples of the thorax show that this species possessed at least eight segments; the thorax has been found partly rolled, and also extended at length.

BERGERONIA ARTICEPHALA Pl. x., figs. 5 *a* and *b*.

Agraulos (?) *articephalus*, Trans. Roy. Soc. Can., vol. iii., p. 65, pl. vii., figs. 14 *a* and *b*.

Ellipsocephalus articephalus, Trans Roy. Soc. Can., vol. xi., p. 104, pl. xvii , figs. 8 *a* and *b*.

Numbers of the head shields of this species have been found, but all from the same horizon, viz.: sandstones of Assise 3.

A pygidium occurs in association with the heads of *B. articephala* but not attached; the rachis has three grooves, and the same number of grooves appear on the side lobes. The rarity of pygidia in Band *b* is remarkable, this being the only one found among hundreds of heads.

* In the figure given in "Fauna of the Olenellus Zone," this species is represented as having a short eyelobe, but this appears to be an error of the engraver, as the description indicates a long eyelobe.

LIST OF THE SPECIES OF BAND *b*, SHOWING THE HORIZONS AT WHICH THEY ARE FOUND. ("rep" = represented.)

	Hanford Brook (Southern Basin).					Northern Basin.		Olenellus Zone.
Assise	1	2	3	4	5	2–4	5	
FORAMINIFERA.								
Orbulina cf. universa		x						
Orbulina (?) ovalis		x						
Orbulina intermedia		x						
Orbulina (?) ingens		x						
Globigerina cambrica		x						
Globigerina grandis		x						
Globigerina didyma		x						
Globigerina turrita		x						
SPONGIDA.								
Monadites		x						
Protospongia		x						
Astrocladia (?) elongata							x	
Astrocladia (?) elegans							x	
Astrocladia (?) virguloides				x				
BRACHIOPODA.								
Lingulella Martinensis	x		x					
Lingulella cf. granvillensis, Walc	x	x						rep.
Obolus (Botsfordia) pulchra						x		
Obolus pristinus		x						
Trematobolus insignis		x						
Obolella nitida, (?) Ford	x							x
Linnarssonia transvera, Hartt					x			rep.
Acrotreta gemma, Bill.	x							x
Acrotreta gemmula		x	x					
Lingulella (?) cælata, Hall	x							x
Lingulella (?) inflata	x							
var. ovalis	x							
Acrothele Matthewi, Hartt								rep.
var. prima			x					
var. lata			x					
var. costata		x			x		x	
Orthid, sp.	x							
MOLLUSCA.								
Hyolithellus micans, Bill.?		x						x
Coleoides typicalis, Walc.?		x						x
Orthotheca cf. Emmonsi, Ford		x						rep.
Hyolithes cf. princeps, Bill			x					rep.
Hyolithes americanus, Bill			x					x
Hyolithes cf. obtusa, Bill			x					rep.
Hyolithes decipiens		x						
Hyolithes gracilior			x					
Diplotheca hyattiana			x					
Diplotheca acadica var. crassa			x					

LIST OF THE SPECIES OF BAND *b*.—*Continued.*

	Hanford Brook (Southern Basin).					Northern Basin.		Olenellus Zone.
Assise	1	2	3	4	5	2–4	5	
Pelagiella atlantoides		x	x					
Volborthella tenuis, Schmidt							x	
OSTRACODA.								
Hipponicharion Eos	x							
Hipponicharion cavatum	x							
Hipponicharion minus			x					
Beyrichona papilio				x				
Beyrichona tinea				x				
Beyrichona planata		x						
Beyrichona triangularis		x	x					
Beyrichona ovata		x						
Beyrichona rotundata		x						rep.?
Aparchites secunda			x					
Primitia aurora	x							
Primitia oculata			x					
Primitia (?) fusiformis			x					
Schmidtella cambrica			x					
Leperditia ventricosa	x							
Leperditia Steadi	x							
Leperditia (?) minor			x					
Leperditia primæva			x					
PHYLLOPODA.								
Lepiditta sigillata			x					
TRILOBITA.								
Protagraulos priscus			x					
Ellipsocephalus galeatus			x					
Ellipsocephalus grandis		x						
Ellipsocephalus sp.	x							
Micmacca Matthevi			x					
Micmacca van Ingeni			x					
Micmacca recurva			x					
Micmacca (?) plana			x					rep.?
Avalonia acadica			x					rep.
Protolenus paradoxoides			x					
Protolenus bituberculatus			x					
Bergeronia elegans		x						rep.
Bergeronia articephala			x					

Comparisons and Conclusions.

In conclusion a few of the salient features which separate this fauna from all others, may be briefly given.

*All the trilobites have continuous eyelobes.** This is decidedly a primitive character, and its value in this respect can be shown from the genus Paradoxides, which began with small species having such eyelobes, and culminated in the large forms in which the eyelobe at maturity, was considerably shortened. This shortening up of the eyelobe was carried still further in the Oleni, dwarfed forms of similar type in the Upper Cambrian; in these the eyelobe comes almost opposite the front of the glabella.

The important family of the Ptychoparida is absent. This family did not have continuous eyelobes, for in the young when this protecting fold first shows itself, it is short, and at the lateral margin of the head-shield. No trilobite with such an eyelobe has been found in this fauna. The Ptychoparida had about a dozen species in the Olenellus Fauna and became quite common in that with Paradoxides, continuing to abound throughout the Cambrian Age.

The genus Conocoryphe is absent. This is specially a type of the Lower Paradoxides beds, and under the name of *Conocoryphe trilineata* (*Atops trilineatus*) is claimed as a characteristic fossil of the Olenellus Zone.†

The genus Microdiscus is absent. This trilobite is specially characteristic of the Olenellus Zone, and continued to live with Paradoxides. In New Brunswick it occurs in the Paradoxides Zone, but not with Protolenus. In Europe it is only known to have lived with Paradoxides.

The genus Olenellus is absent. Though carefully looked for,

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* That is, eyelobes that extend from near the front of the glabella to the posterior marginal furrow.

† This however, is probably an error, for the genus Conocoryphe is characteristic of the Paradoxides Fauna, and eminently of the Lower Paradoxides beds. It is found in this relation in Scandinavia, where, including Ctenocephalus, which has a similar range, no less than six species occur, all in the Lower Paradoxides beds; and four in Wales. In Bohemia also the genus occurs in the same connection, as also in the north of Spain and south of France. In New Brunswick it is equally characteristic of the same horizon, as may be seen by reference to the author's list showing the range of Cambrian species in this country (Trans. Roy. Soc. Can., vol. xi., pt. iv., p. 118); and although the species *Conocoryphe trilineata* has not been found here, the author has met with it in a collection of fossils from the Paradoxides beds of Manual Brook, Newfoundland, sent to him by Mr. J. P. Howley. It is altogether probable that the Paradoxides Fauna is present in the slates of Washington county, N.Y., where *Atops trilineatus* occurs, but has not been recognized. The author several years ago drew attention to the place of this genus in the chronological succession of the Cambrian genera in Trans.Roy.Soc.Can., vol. iv., pt. iv., p. 149. *Olenellus asaphoides* and *Conocoryphe* (*Atops*) *trilineatus*, which Emmons proclaimed as the characteristic fossils of his Taconic System, are types, the one of the Olenellus Zone and the other of the Paradoxides Zone, and sustain Emmons' contention that his Taconic rocks were below the Potsdam sandstone.

no example of this genus has been found among the trilobites of Band *b*. Hence, though the Protolenus Fauna holds the place where we might naturally look for Olenellus, this genus is absent, and as so many of the genera associated with it are also absent, *we cannot regard this fauna as the Fauna of Olenellus.*

Of the genera of trilobites that are present Micmacca has close relationship with Zacanthoides; it differs in the course of the posterior extension of the dorsal suture. The relation will seem closer if we suppose a movement of the eyelobe during the growth of the individual in Zacanthoides, similar to that which occurred with the Ptychoparida, in which there was a contraction of the eyelobe toward the glabella during growth and at the same time a projection of the posterior extension of the dorsal suture outward, toward the genal angle. If this relation should be established, Micmacca may be looked upon as an ancestral form of Zacanthoides.

It is worthy of note that in two of the genera of trilobites that occur in the Protolenus Fauna, the earlier species are larger than the later, as though these genera had reached their culminating point, and were on the decline; these types are Bergeronia and Ellipsocephalus; and as regards the latter, the continued diminution in size is notable in the sole species of this type in the Paradoxides Zone, viz.: *E. Hoffi.**

Among the Ostracoda of this fauna, a diminution in size is found in the successive species of Hipponicharion, and of one section of Beyrichona (*e. g., planata* and *tinea*). The former genus is among the first crustacean remains of these Cambrian beds.

In this fauna we find ourselves among a very primitive assemblage of Brachiopods, for among them are forms which it is difficult to assign to any known genus. Many are small, some are minute, and the larger forms all belong to the Obolidæ and Siphonotretidæ. One of the latter is remarkable as being of the inarticulate order, yet having a distinct articulation at the hinge-line.

The Gasteropoda are all of aberrant types. This class is chiefly represented by various forms of Hyolithidæ, the most ancient of all known types of Gasteropods, having come down to this fauna from Pre-Cambrian times.† A very remarkable form of this fauna is Pelagiella, which is probably an oceanic Heteropod of large size. The mouth of the shell is such as no crawling mollusc would have possessed.

Finally may be mentioned the Foraminifera, of which several genera are present, the most common being Orbulina and Globi-

* *E. Germari* of Bohemia is too aberrant to be included with the earlier types.

† It is represented by Orthotheca in the Etcheminian series, 1200 feet below.

gerina. At the present day these genera have left their remains most freely in deposits which lie under a depth of oceanic waters of 1000 to 2000 fathoms. Their remains are most abundant in Assise 2, though they occur also in Assise 3.

This fauna is distinguished from that of Olenellus by two marked features. It is more *primitive* and also more *pelagic.* The way in which the trilobites are bound together by the single feature of a continuous eyelobe shows a unity of origin and a closer relationship than is found in the trilobites of any other fauna, and yet among these trilobites there are forms which in other respects are parallel to the types which developed in the later faunas. Thus in Protolenus we have the flat pleuræ, with diagonal furrow of Paradoxides, but in sub-gen. Bergeronia the deeply grooved, geniculated pleuræ of Ptychoparia, and at the same time the prominent glabella and deep dorsal furrows of Solenopleura. Micmacca, as has already been said, predicates Zacanthoides of a later fauna. Finally, Protagraulos, in its almost obliterated glabella and flat cephalic shield recalls Agraulos and Holocephalina of the Paradoxides fauna.

It is a more *pelagic* fauna than that of Olenellus, for we notice the absence of many forms of the Olenellus Fauna that were differentiated for shore-conditions. Trilobites with fixed outer cheeks like Olenellus and Microdiscus are absent; calcareous corals and sponges are rare, and no Lamellibranch is known. On the other hand, Foraminifera are quite common in some layers, and the Gasteropods are mostly such as were adapted for comparatively deep water.

If then this fauna is not that of Olenellus, but one that is more primitive and more pelagic, should we look for Olenellus above or below Protolenus? It is to be noted that there remain several Assises near the base of the St. John group which have not yielded a fauna of trilobites, so that there are still possibilities of the recovery of this genus from these Cambrian rocks. In the first assise of Band *b.* only an imperfect Ellipsocephalus has been found, but some of the Brachiopods of this assise are identical with those of the Olenellus Zone. However, the crustaceans so far recovered from this assise show no special resemblance to those of the Olenellus Zone.

A consideration in this connection is that the two faunas may have been cotemporary, but incapable of existing in the same area, owing to their being adapted to different conditions of depth and temperature. If, for instance, the Protolenus Fauna was fitted for deeper and more tranquil waters than that of Olenellus, we would expect that at a locality where the two faunas occurred in succession in a series of deposits, the Olenellus Fauna would be found beneath that of Protolenus, for the reason that where consecutive deposits are laid down in a given basin or on a given area of the sea-bottom, the littoral fauna will appear first, *i. e.*, at the bottom of the deposit, while those of the deeper water will come in higher up. This is a natural consequence of the continuous and steady sinking of the earth's crust over a given area. If there should be oscillations in the movement, *i. e.*, alternate sinking and elevation, there will be lacunæ in the faunas, as in the Lower Cambrian of Russia, or the Upper Cambrian of Bohemia and northern Newfoundland. But the movement of depression in New Brunswick throughout Cambrian Time was fairly continuous, and subject to only moderate variation, and especially in the Pre-paradoxides beds, so that the fauna of Olenellus may yet be found in close relation to that of Protolenus.

Assises 4 and 5, as already remarked, show no trilobite fauna, and this seems the more probable place for the Olenellus Fauna, seeing that while this fauna has several genera of trilobites in common with the Paradoxides Fauna, it has but two that are found in the Protolenus Fauna.

Finally, it should be remarked that the above conjectures as to the characteristics of the Protolenus Fauna and its relations to others, are based on *our present knowledge* of its constitution and peculiarities. Possibly further knowledge may make it necessary to modify these remarks in some particulars, but the fauna is now so well shown by the numerous species pertaining to it, that these modifications cannot essentially change its aspect, or obliterate its peculiar and essential characters.

Stated Meeting.

March 25th, 1895.

The Academy met and listened to the fifth public lecture of the course for 1894–95, by Prof. M. I. Pupin, on "Tendencies of Recent Electrical Research."

100 persons were present.

Before adjournment the following persons were nominated for resident membership and referred to the Council:

Robert Center, Thomas C. Meyer, Samuel W. Bridgham, Lloyd Phœnix, George B. Post, Peter Marié, Charles F. Lembke, S. Nicholson Kane, Charles A. Macy, 2d.

J. F. KEMP,
Recording Secretary.

STATED MEETING.

April 1st, 1895.

The Academy organized with Pres. Rees in the chair. Thirteen members were present.

The following names having been approved by the Council were elected as resident members of the Academy:

Thos. C. Meyer, Lloyd Phœnix, Robert Center, Chas. F. Lembke, Samuel W. Bridgham, S. Nicholson Kane, Peter Marié, Geo. B. Post and Chas. A. Macy, 2d.

The following were nominated as resident members by William Hallock and seconded by C. C. Trowbridge:

Herschell C. Parker and Herbert T. Wade, Department of Physics, Columbia College.

The Section of Astronomy and Physics then organized with Chairman J. K. Rees in the chair.

Prof. Rees read by title a paper by Herman S. Davis, Fellow in Astronomy, Columbia College, on the "Declination of sixty-two stars near η Cassiopeiae." William Hallock read by title a paper by R. A. Millikan, late Fellow in Physics, Columbia College, on "The Polarization of Light by Emission."

Officers of the Section for the ensuing year were elected as follows: R. S. Woodward, Chairman; William Hallock, Secretary.

Pres. Rees then gave a very comprehensive resumé of the progress of astronomy during 1894.

On motion, the thanks of the Academy were tendered to Prof. Barnard, of Lick Observatory, and Prof. Keeler, of Alleghany, for their kindness in sending photographs for exhibition at the reception and at this meeting.

Pres. Rees then showed Barnard's photographs of the Milky Way and of several comets, especially Brooks'. They were discussed by Pres. Rees, Mr. C. A. Post and others. Adjourned.

WM. HALLOCK,
Secretary of Section.

A STUDY OF THE POLARIZATION OF THE LIGHT EMITTED BY INCANDESCENT SOLID AND LIQUID SURFACES.

BY R. A. MILLIKAN.

I.

INTRODUCTORY.

In spite of the prodigious activity of physicists during the first three quarters of this century in attacking the problems of reflection, refraction, and polarization in all their different phases, both from the side of experiment and that of mathematical theory, the problem of polarization of light by emission seems to have received comparatively little attention. Although the fact that incandescent solids and liquids emit, at oblique angles of emergence, partially polarized light, was discovered more than seventy years ago, it does not appear even to-day to be very generally known. Few, even of the more complete text-books on Physics, make any mention of the fact. Verdet, in his "Optique," published in 1870, devotes a short paragraph to "Polarization by Emission," in which he says that "there exists upon the subject but a small number of experiments due mainly to Arago." The summary of these experiments which he subjoins, reveals none whatever which are quantitative. Since the time of Verdet, no one, so far as I am able to discover, has made any careful or elaborate study of the phenomenon with a view to ascertaining its generality, verifying or disproving Arago's assumption as to its cause, or classifying different substances with reference to their power of producing the phenomenon in greater or less degree.

Since even a hasty examination reveals the fact that different substances emit light of widely different percentages of polarization, it appears that a study of the relations of different bodies in this respect ought either to add something to our knowledge of the optical properties of the substances considered, or else, if this particular property is deducable from the already known properties, as Arago assumed it to be, its relation to these properties ought to be definitely proved. This investigation has therefore been undertaken for the purpose, first, of making a somewhat wide range of qualitative experiments upon the nature and generality of the phenomenon; and, secondly, of subjecting Arago's explanation of the cause to the test of comparison with carefully determined experimental quantities.

II.

Historical Review.

The simple facts of polarization of light by emission can best be observed, and in fact were first noticed, upon platinum. If a sheet of that metal be heated to incandescence in the flame of a Bunsen burner, and the emitted light examined by means of a Nicol prism, or any other instrument adapted to the detection of partially polarized light, it will be observed that when the experimenter is viewing the surface normally the emitted light exhibits no trace whatever of polarization, but as the instrument is inclined so as to receive rays emerging obliquely from the surface, the light begins to show evidences of polarization in a plane perpendicular to the plane defined by the normal and the emerging ray. If this plane be called the plane of emission, and the angle included between these two directions *the angle of emission*, the complete phenomenon may be roughly described by saying that the polarization increases as the angle of emission increases, and becomes, in the case of platinum, exceedingly strong as the emission angle approaches ninety degrees.

The announcement of this fact, and the consequent overthrow of the common belief that light coming immediately from self luminous bodies is always natural, was first made in 1824 by Arago. In a report made in that year to the Royal Academy of Sciences (see Annales de Chemie et de Physique (1) 27, p. 89.) he announced that he had some time before made a series of experiments upon the light which emanates from incandescent bodies. "He found that if the bodies are solid or liquid this light is partially polarized by refraction when the rays observed form with the emitting surface an angle of a small number of degrees. As for the light of an ignited gas it presented under no inclination traces of sensible polarization." From these experiments he drew the conclusion "that a considerable portion of the light which enables us to see incandescent bodies is produced in the interior and at depths which are not yet completely determined." "Even when the surface of a solid or liquid was not well polished," Arago still found that he "was able to detect evident traces of polarization." The substances upon which he experimented and from the observation of which he drew his conclusion were only four in number, viz.—solids, wrought iron and platinum; liquids, molten iron and glass (See Astronomie Populaire II., p. 103.). He made *no* quantitative measurements, nor even used an instrument which was capable of indicating roughly *amounts* of polarization. His polariscope consisted of a single quartz crystal cut perpendicularly to the optical axis and a crystal of Iceland spar. The latter produced a double image of an opening in a diaphragm placed just beyond the crystal of quartz. The two images were of course colored when the light was polarized and uncolored when it was natural.

Arago applied the results of his experiment to the determination of the character of the sun's surface. Being unable to detect any trace of polarization in the light emitted by the outer edge of the sun's disk, he drew the well-known conclusion that the surface of the sun can be neither liquid nor solid, but must be gaseous.

After the discovery of the polarization of heat, and the construction of an instrument by Melloni for its detection and measurement, Provostaye and Desain examined the heat rays emitted by luminous platinum and found that they, like the light rays, were polarized in the plane perpendicular to the plane of emergence. Their experiments were few in number and confined entirely to platinum. In 1866 Magnus extended this method of experiment to obscure heat rays, making quantitative measurements upon the heat emitted at the temperature of 100° C, and at an angle of 35°. His experiments embraced the following list of substances: Paraffine, glycerine, white wax, melted calophony, rubol, black glass, transparent glass, quicksilver, aluminium, copper and tin. For these substances he found a polarization at 35° ranging from 5% to 27%. He drew the conslusion that obscure heat, like light, must undergo refraction in emerging from the surface of the radiating body.

Verdet, in the paragraph upon polarization by emission previously referred to, while stating that little has been done in the investigation of the subject, gives the same explanation of the phenomenon as that first offered by Arago. He says that "it is due to the fact that it is not alone the surface molecules which radiate light; those of the interior layers also radiate, at least to a certain depth; and the rays emitted by the interior molecules undergo refraction at the surface." Since the time of Verdet, I believe no one has made any experiments upon the subject except Violle, who has a brief note in the Compte Rendu of 1887, Vol. 105, p. 111, in which he states that, while making some other experiments upon molten silver, he took occasion to measure the percentages of polarization in the light emitted by that substance at various incidences. He plotted the curve of these percentages and found that it was very well represented by the empyrical formula $p_e = (1 - \cos i)(1 + \cos 75^\circ + \frac{1}{5})$, where p_e represents the ratio of polarized light to the whole light in the emitted beam and i the angle of incidence.

Assuming, then, the phenomenon to be due to refraction, he argues that the equality of the amounts of polarization in the reflected and refracted beams would require that $e\ p_e = r\ p_r$, where e is the proportion of the whole light emitted, r the proportion reflected, p_e the proportion of polarized light in the emitted beam, and p_r the proportion of polarized light in the reflected beam. Then, since the whole light is either emitted or reflected, $e + r = 1$, and the formula $r = \frac{pe}{pe + pr}$ immediately follows. Taking the experimental values which have been determined for p_r by reflection at ordinary temperatures, he finds that his own results for p_e, when substituted in this formula, give a uniformly high reflecting power for molten silver; a result which agrees with the known properties of ordinary polished silver. This forms the nearest approach to a verification of Arago's assumption which has yet been given.

Such is the extent of the work which has thus far been done upon polarization by emission.

III.

Discussion of Arago's Explanation.

The explanation of Arago and Verdet is as yet the only one which has been offered to account for the phenomenon. This explanation does not rest upon careful experimental proof, and, furthermore, there seems to be considerable reason for doubting its correctness. According to that explanation the light which comes to the eye from the *surface* particles is *natural* light; but mixed with this unpolarized light is a quantity of light which has worked its way up from uncertain depths, has undergone reflection and refraction at the surface, and is consequently polarized upon emergence. Aside from the intrinsic difficulty of this conception, the first experiments which were made in this research upon platinum seemed to be inconsistent with such an explanation; for, when a well polished platinum strip was heated to incandescence by means of an electric current and the glowing surface examined by means of a double Wollaston prism, the polarization was found to be so nearly complete for angles in the neighborhood of grazing emergence that one of the images almost disappeared. But, since platinum is known to be altogether opaque, except in the case of exceedingly thin laminæ, it would seem as though the surface molecules must play a considerable part in the luminosity of the glowing metal; so that, even if the assumption were made that the laws of reflection and refraction would require complete extinction of the ray polarized parallel to the plane of emergence, there still ought to be a considerable amount of light emitted in this plane from the surface molecules; at least, a sufficient quantity to prevent so nearly complete extinction as experiment showed to exist for angles of 88 or 89 degrees.

The only apparent method of reconciling the facts with Arago's explanation was to assume that the opacity of the platinum was greatly diminished by an increase in its temperature. And yet, such experiments as were made to determine whether or not this was the case, gave only negative results. The thinnest sheet of platinum which was capable of being heated to incandescence without melting, was placed in the focus of a powerful beam of light from an arc lantern, the beam having been first polarized by transmission through a Nicol. The plane of the glowing platinum being perpendicular to the beam, the light emerging normally on the other side of the platinum was examined by means of a delicate polariscope. No trace of polarization was detected. Neither could the outlines of the focus be distinguished on the side of the platinum away from the lantern. The sheet of platinum employed was evidently just as opaque as at a lower temperature.

This difficulty of accounting for the extreme polarization noticed at large angles of emergence appeared to be considerably diminished if another cause for the phenomenon were assumed than that given by Arago.

According to the conclusions of Fresnel, Cauchy, Stokes, Mascart and most of the advocates of the elastic solid theory of light, the direction of vibration of the ether particles in plane polarized light is perpendicular to the plane of polarization. It would follow that the light emitted at large angles by platinum vibrates mainly in the direction of the normal to the surface. It is not unnatural to suppose that at the boundary between very dense and very rare media, like platinum and air, there may be less resistance to vibration in a direction away from the surface than in a direction parallel to the surface, and therefore that the light emitted is composed mainly of vibrations in a direction normal to the surface. If this were the case the light emitted normally would be unpolarized, while that emitted at oblique angles would be polarized in the plane perpendicular to the plane of emission. Furthermore, the polarization would increase with the angle and might be very great at large angles, in case the difference in density between the two media were very great—conclusions all of which are in accordance with the facts. In view, then, of the inability to account, by Arago's assumption, for the extreme polarization at large angles of emergence, and in view of the plausibility of the other explanation, the following qualitative experiments were made in order to determine with more certainty the nature of the phenomenon.

IV.

Qualitative Experiments.

The object of this part of the research was:

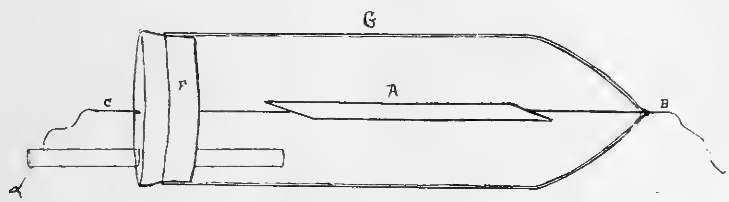
(1) To make certain that the property of polarization is due to the incandescent body itself, and is not caused by the refraction of the light as it passes through the layers of air of varying density which rest upon the luminous surface; and,

(2) To make observations upon as wide a range of substances as could be made to emit light without combustion, in order to ascertain whether any substance could be found which does not possess the characteristic, and also in order to determine in a general way the relations of different bodies with reference to this property.

For these purposes two instruments were employed; the first, a polariscope similar to that of Arago, save that the simple quartz crystal was replaced by a bi-quartz plate, and the crystal of calc-spar by a double Wollaston prism. This is the same instrument which was afterwards used by Arago in his polarimeter, and it has an advantage over the first form in that the two colors to be compared are brought into immediate juxtaposition. It is delicate to the extent of detecting a polarization of about 3% (as was shown by succeeding experiments), when white light is under examination. When the light to be tested is monochromatic, as was the case in some of the following experiments, the second form of polariscope was found to be preferable.

In this instrument the bi-quartz is replaced by a cube of glass which has been subjected to strain in cooling. A Nicol also takes the place of the Wollaston prism of the first polariscope. The glass, being in a state of strain, is doubly refracting and exhibits with polarized light the familiar dark or light cross which is characteristic of doubly refracting crystals, when cut perpendicularly to the optic axis and viewed by convergent light. With this instrument a polarization of two or three per cent. could be easily detected, and it had the further advantage of indicating immediately the azimuth of the plane of polarization. Also, by careful observation of the distinctness of different parts of the figure, it was possible, after a small amount of practice, to estimate with considerable correctness the *degree* of polarization.

4. In all experiments which have been previously performed upon this subject, the white-hot body has been in immediate contact with the air. The emitted light was therefore obliged to pass through layers of air of varying density before it reached the eye of the observer. That the light might not thus suffer



a large number of refractions between the incandescent body and the eye, and so be endowed with the property in question, seemed entirely possible. It was therefore necessary to make some experiment in order to determine whether or not this was the entire or partial cause of the phenomenon. For this purpose the contrivance shown in the diagram was employed. A strip of platinum foil A about four cm. in length and five mm. in width was attached to the platinum and copper wires B and C. The former was sealed into the glass tube G, and the latter was passed through the cork F which closed the other end of the tube.

The instrument was first sealed with wax and then connected with the air pump by means of the small tube D, and with a strong electric current by means of the wires B and C. Care was taken to place the platinum strip as near the axis of the tube as possible, in order that light emitted by it might pass normally through the sides of the tube. Otherwise polarization would have been caused by the passage of the beam through the glass itself. The tube being exhausted until the gauge showed a pressure of only four millimeters, the current was turned on and the glowing strip examined by means of the bi-quartz polariscope. The emitted light was still found to be polarized for oblique angles of emergence, and did not appear to have undergone any change in intensity. In order, however, to ascertain whether or not the effect of the air was altogether negligible, more delicate experiments were necessary. These will be hereafter described.

It may also be added at this point that experiments were made upon the glowing platinum by means of a Jamin compensator, in order to make certain that the light under consideration was simple partially polarized light, and not elliptically polarized. From our knowledge of the way in which elliptically polarized light is produced, viz., by causing retardation or acceleration in one of the components of plane polarized light, it would immediately be inferred that the light emitted by the platinum is not elliptically polarized, since there is no reason to suppose that it was at first *plane* polarized. The correctness of this conclusion was immediately shown by the use of the compensator. For, the compensator having been set at zero by the use of plane polarized light, when the beam of light from the platinum was made to fall upon the instrument, the dark central line showed no displacement whatever from the zero position. Had the light been elliptically polarized the black central line would have been of necessity somewhat displaced, no matter what angles the compensator planes made with the rectangular axes of the ellipse. Furthermore, for elliptically polarized light there is always some position of the analyser which gives an absolutely black line, whereas, if the light is partially polarized, the line can never be any darker than the field which is illuminated by that quantity of natural light which is contained in the partially polarized beam. Applying these considerations to the light emitted by the platinum it was shown without question that the light is partially and not elliptically polarized.

2. Having thus examined the nature of the light, and proved that the phenomenon is inherent in the body itself, experiments were made upon the following substances with results as indicated.

SOLIDS.—*Metallic.*

Platinum (polished).—Polarization very strong near grazing emergence, but falling off rapidly as the angle diminishes. Scarcely perceptible at ten degrees.

Silver.—Polarization strong, larger for small incidences that in the case of platinum.

Gold.—Polarization strong ; similar to platinum, but apparently less for large angles.

Copper.—Polarization weak, probably due to roughening of surface through oxidization.

Brass.—Polarization weak—(oxidization).

Iron.—Polarization weak—(oxidization).

SOLIDS.—*Non-metalic—transparent.*

Glass.—Polarization weak ; imperceptible except at large angles of emergence.

Mica—Polarization weaker than in glass. Surface roughened by heat.

SOLIDS.—*Non-metallic—opaque.*

Porcelain—Polarization similar to that produced by glass.

Black Glass.—Polarization similar to that produced by transparent glass.

LIQUIDS.

Molten Silver }
" Gold } Polarization similar to that in solid state.

" Iron.—Polarization strong ; almost as strong as in molten gold.

" Bronze.—Polarization strong ; almost as strong as in molten gold.

Lead.—Polarization weaker than for preceding metals. (Difficult to get a clear surface).

Zinc.—Polarization weaker than for preceding metals.

From these experiments it will be seen, 1st, that the metals show uniformly high percentages of polarization so long as the surface is non-diffusing; 2nd, that none of the non-metallic substances used produce strong polarization at any angle ; 3rd, that the transparency or opacity of a substance has apparently little effect upon its power of producing polarization in the emitted light ; and, 4th, that any cause which interferes with the perfect smoothness and regularity of the surface destroys in large measure the polarization.

V.

INSTRUMENT EMPLOYED FOR QUANTITATIVE EXPERIMENTS.

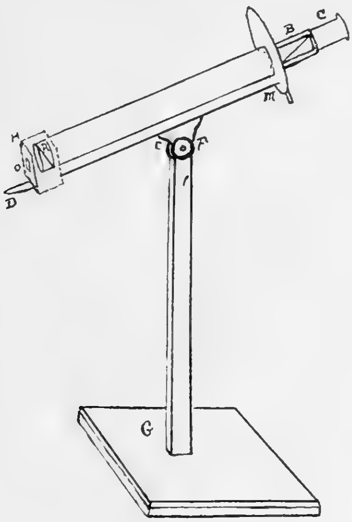
In order to accomplish the second and main object of the research, it became necessary to devise some means of making accurate determinations of the relations of the *constants* of the partially polarized beam. In case of elliptic polarization the constants are best determined by means of a Babinet compensator, but this instrument fails entirely for partially polarized light. The instrument which has been most employed for such work by previous investigators is the Polarimeter of Arago.

This is an instrument simple enough in principle, but difficult in construction. Moreover it does not possess a very high degree of accuracy, owing to the fact that its use depends upon the detection, by means of a bi-quartz polariscope, of the exact point at which all polarization disappears from a beam of light. The beam of light to be examined for polarization is made to pass through a pile of glass plates set in such a manner with reference to the beam as to produce, by refraction, polarization in a plane at right angles to the plane in which the beam is already partially polarized. The inclination of the plates is altered until the halves of the bi-quartz plate show no traces of color. The instrument having been previously graduated by means of a beam of known polarization, the amount of polarization in the beam in question can be immediately read off upon the graduated circle.

The graduation is effected by passing a plane polarized beam through a thick crystal of Iceland spar. Then, by the Law of Malus, the polarization in the transmitted beam is given by the cosine of twice the angle included between the plane of polarization of the incident beam and the principal plane of the crystal.

Both because of the difficulty of construction of this instrument, and because my own experiments with the bi-quartz polariscope made me distrustful of the accuracy with which the point of no polarization could be determined, another form of instrument was devised for these experiments which is greatly superior to the Arago polarimeter in simplicity, and is probably more than equal to it in accuracy. The instrument had been constructed and used for several months before the discovery was made that the credit of the first conception and use of this method of measuring the constants of partially polarized light is due to Cornu.

In view of the exceeding naturalness and simplicity, as well as the accuracy of the method, it is surprising that it was not earlier discovered and has not been more generally employed. Cornu's description of his instrument was published in '82 in the "Ass'n Francaise pour L'Avancement des Sciences, Compete Rendu;" but so far as I can discover, no reference was made to it at the time in any of the scientific journals, nor has it taken its place among other polarimeters in any of the text books on optics. The instrument as constructed and used for the purposes of these experiments was as follows. A rectangular opening O., 1 mm. in width and 2.5 mm. in length, was made in a diaphragm H. which stood a short distance in front of the double Wollaston prism A. The prism was rotated until the extraordinary image of the opening was to the left of the ordinary; the distance of the screen from the prism was then adjusted until the opposite edges of the two images exactly coincided. A Nicol prism B, capable of rotating about its axis and furnished with a graduated circle and vernier for reading azimuth to a tenth of a degree, constituted the only other essential part of the instrument. A small telescope C was used for viewing the images of the rectangular opening O. The instrument was mounted upon a support G, furnished with a horizontal axis at F, about which the upper portion of the apparatus could be revolved. The axis of the tube bearing the double prism and Nicol could thus be in-



clined so as to make any desired angle with the vertical. Since the two images furnished by the double prism consist of light polarized in planes at right angles to each other, the rotation of the Nicol will evidently extinguish each of them in turn. There will be four extinctions in the course of a complete revolution of the Nicol, and between any two extinctions there is a point for which the images, as seen through the Nicol, have exactly equal intensities. If now a partially polarized beam is under examination, and if, the plane of polarization of this beam being known, the principal sections of the prism are set parallel and perpendicular to this plane, that position of the Nicol which equalizes the two images, evidently defines the relation between their original intensities, which is also the relation between the constants of the partially polarized beam.

If we let a and b represent the original amplitudes of vibration in the two images, then the intensities of these images are represented by a^2 and b^2 respectively. The proportion of polarization is evidently the difference between these intensities divided by their sum. If w is the angle which the transmitting plane of the Nicol makes with the direction of vibration of the more intense of the two beams, say a^2, then the intensities of the two images as seen through the Nicol will be, by the law of Malus,

$$a^2 \cos^2 w \text{ and } b^2 \sin^2 w. \quad (1).$$

Hence for the position of equality we have,

$$a^2 \cos^2 w = b^2 \sin^2 w. \quad (2),$$

or $$\frac{a^2}{b^2} = \frac{\sin^2 w}{\cos^2 w} \quad (3)$$

If we call the degree of polarization in the original beam p, we have

$$p = \frac{a^2 - b^2}{a^2 + b^2} \quad (4) \text{ or, from } (3)$$

$$p = \frac{\sin^2 w - \cos^2 w}{\sin^2 w + \cos^2 w} = - \frac{\cos^2 w - \sin^2 w}{1} = - \cos 2\, w. \quad (5)$$

Hence, when the position of the Nicol which produces equality in the images has been found, the amount of polarization is immediately given by (5).

Cornu, in discussing the instrument, shows in addition, that, when the principal sections of the partially polarized beam are not known, the degree of polarization may still be found by taking one set of readings in any position whatever of the axes of the double prism, and then rotating the whole instrument through an angle of 90° and taking a second set of readings. The degree of polarization can then easily be shown to be given by the formula

$$p = \sin\, (w_2 - w_1)$$

In this work, however, we are not concerned with this last formula, since the principal sections were always known.

VI.

Adjustment of the Instrument.

Since the series of experiments here considered were all made upon horizontal surfaces, and since the polarization of the emitted light is always in a plane normal to the surface, but one adjustment of the instrument was necessary, viz., that of bringing the principal sections of the double prism unto coincidence with the horizontal and vertical directions.

This adjustment was effected in the following way. The axis of the tube bearing the prism and Nicol was first set, by measurement, parallel to the cross-piece D M of the supporting frame. The base G was then carefully levelled by means of a common level. The levelling of D M then brought the axis of the tube into coincidence with the horizontal line. The telescope was then focussed upon a very fine line of light reflected from the edge of a carefully levelled sheet of white paper placed just in front of the rectangular opening O. Since the line joining the two images produced by a crystal of calc-spar is always paralled to the optical axis of the crystal, it follows, that, when the two images of the horizontal line of light form with each other an unbroken line, the principal sections of the crystal have the desired directions, and the adjustment is perfect. The line of light used in this case was so narrow that the adjustment was able to be made with great accuracy. This done, the crystal was permanently fastened in position. Thereafter, it was only necessary, before each observation, to level the base of the instrument G, in order to bring the principal sections of the crystal into the desired positions.

In order to set the axis of the tube at any desired angle with the vertical, the cross-piece D M, parallel to this axis, was levelled, and the angle D E G, between the movable arm and the vertical support, was measured by means of a protractor. The zero position being thus determined, any desired inclination could be secured by giving to the angle D E G the proper value.

VII.

Degree of Accuracy of the Instrument.

The great sensitiveness of the eye in detecting slight differences in the intensities of images of the same color, when brought into close proximity, has often been the subject of remark. Cornu claims that the position of equality can be determined with a precision that reaches $\frac{1}{10}$ of a degree. My own observations would not lead me to attribute to the instrument so high a degree of accuracy. Furthermore these observations are subject to the objection which attaches to all photo-metric experiments, that the sensitiveness of the eye varies greatly with the physical and mental condition of the observer. At times the extreme difference in my readings for a given set of conditions would be as high as $2\frac{1}{2}$ degrees. Usually, however, the extreme difference was not more than $1\frac{1}{2}$ degrees. For the sake of testing the probable accuracy of the results which are to be given later, several sets of observations were made upon the unpolarized light of a gas flame. The following illustrate about the average course of the readings. The zero of the instrument not being known, the positions of equality on each side of the positions of extinction were determined:

Left.	Right.
50.5	39.2
50.0	39.1
50.0	38.7
50.4	38.8
51.3	40.0
50.0	40.0
51.0	40.0
51.1	39.9
50.2	39.2
49.5	39.0
50.4	39.37

$$2\,w = 89.77$$
$$w = 44.88$$

Since the light from a gas flame is unpolarized, the value of w should have been 45°. The difference is not large, but is slightly greater than the maximum error ascribed to the instrument by Cornu. The above is about an average set of readings. The extreme difference is 1.8°, a difference perhaps slightly greater than that usually found.

A second slight error may sometimes arise in the use of this instrument from the fact that the two images produced by the double prism do not correspond to exactly the same points on the luminous surface. Hence, in order that the results may be correct, it is necessary that the adjoining portions of the incandescent surface be exactly alike. In none of the experiments here recorded were the portions of the luminous surface producing the two images more than 3 mm. apart. Care was always taken to direct the instrument toward a portion of the surface which appeared to be entirely uniform. This error may, I think, be safely disregarded in all of the following cases except one, which will be mentioned later.

A third remark which should be made upon the accuracy of the instrument is that observations for large amounts of polarization are less subject to error than those made upon small amounts. For, since the intensities of the two images compared are proportional to $\sin^2 w$ and $\cos^2 w$, the change in intensity of one of them will be very rapid when w is in the neighborhood either of zero or of ninety degrees. When, however, w is near 45°, the change in intensity corresponding to a small change of angle is comparatively small. Hence, when the polarization is large, and w consequently either large or small, the position of equality can be determined with considerably greater accuracy than when the polarization is weak and w in the vincinity of 45°.

The results obtained for large angles may therefore be considered more trustworthy than the results for small angles.

VIII.

Measurement of the Air Effect.

In the qualitative experiments previously described it was ascertained that the amount of polarization was at least not greatly affected by the contact of the air with the heated surface. Before proceeding to careful quanitative measurements it was necessary to determine whether or not its effect upon the phenomenon is altogether negligible. This could be easily done by means of the polarimeter.

The sealed glass tube containing the platinum strip was again connected with the air-pump, and the air exhausted until the pressure was about 4 mm. The current was turned on, the polarimeter arranged so as to receive the light emitted from the glowing surface at an angle of about 80°, and the Nicol turned until the images were brought into equality. The stop cock was then suddenly turned and the air admitted. No change whatever could be perceived in the equality of the images. The experiment was repeated a number of times and in a variety of ways, but always with the same result. The conclusion was, that, if the air has any effect whatever upon the proportion of polarization in the beam, that effect is so slight as to be ALTOGETHER NEGLIGIBLE; a result exceedingly fortunate for the purposes of this investigation, since, had it been necessary to work upon substances in a vacuum, the following experiments would have been much more difficult, if not altogether impossible.

IX.

Experiments upon Uranium Glass.

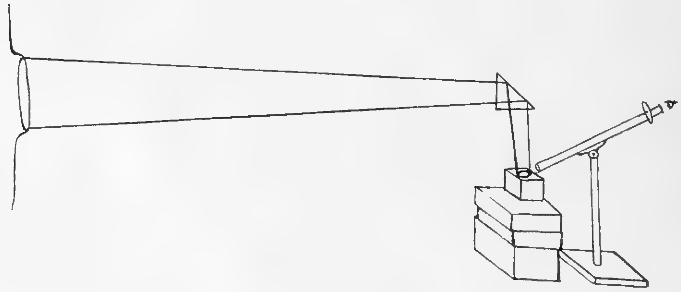
The chief difficulties which beset the investigation of Polarization by emission are, 1st, the difficulty of obtaining a perfectly *definite* and *regular* incandescent surface with which to work; and 2nd, the difficulty of ascertaining with certainty the optical constants of *any* bodies at the temperature of incandescence.

The similarity between a body emitting light by incandescence and a body emitting light by fluorescence was first suggested to me by Professor Rood. According to Tait the phenomenen of fluorescence is confined mainly to the surface layers. Whatever the cause, then, of polarization by emission, the light coming from a fluorescent surface ought to be polarized in the same way as the light coming from glowing platinum.

Experiment showed this conclusion to be entirely correct. The polarization seen in the uranium glass was similar in every respect to that observed in incandescent porcelain, being scarcely discernible at any angle less than 50°, but becoming quite marked between 85° and 90°, and evidently reaching a maximum at grazing emergence.

That this polarization was not due to diffusing particles on the surface was certain for three reasons. 1st. The surface was NOT a diffusing surface except to an exceedingly small extent. 2d. The light which exhibited the phenomenon of polarization was the characteristic yellowish-green light which uranium emits, and not the blue light which fell upon the surface. 3d. The reflecting particles on the surface would have produced a polarization *in* the diffusing plane, *i. e.*, in the plane defined by the direction of the beam which entered the instrument and the direction of the incident beam, which was in this case normal to the surface. As a matter of fact the polarization was in a plane perpendicular to this plane.

Here, then, was an instance of polarization by emission in which the surface was perfectly definite and at the same time the optical constants of the substance could be easily and accurately determined.



Accordingly a careful series of observations was made with the polarimeter. The experiments were all conducted in a well darkened room, and care was taken not to allow any light to enter the instrument except that emitted by the uranium glass. In order to make the determination of the angles of emission convenient, the light from the lantern was thrown vertically down upon the surface of the uranium glass by means of total reflection in a right angled prism. The cube of glass was carefully levelled so that the emitting surface was always horizontal. The arrangement of apparatus is shown in the figure.

Ten readings were taken for every angle of emergence. The results are given in full.

87.5°		85°		80°	
Left.	Right.	Left.	Right.	Left.	Right.
40.5	29.8	42.3	30.7	43.0	32.0
39.5	29.9	43.0	31.2	43.3	32.5
39.8	28.5	42.5	30.5	43.8	32.3
40.0	29.0	41.7	30.9	44.0	32.6
39.0	28.9	40.9	31.0	43.3	32.3
39.76	29.22	42.1	30.86	43.48	32.34
$2w = 68.98°$		$2w = 72.86°$		$2w = 75.82°$	
$p = .358$		$p = .293$		$p = .245$	

75°		70°		65°		50°	
Left.	Right.	Left.	Right.	Left.	Right.	Left.	Right.
44.5	34.5	45.5	35.0	47.0	37	49.1	38.2
45.0	35.0	46.4	36.4	47.2	36.3	48.9	38.2
44.3	35.0	46.5	36.5	47.5	37.5	49.0	38.9
44.5	33.5	47.0	35.0	48.0	37	50.0	39.3
44.5	34.4	46.3	36.2	47.4	36	49.3	39.0
44.56	34.5	46.34	35.8	47.62	36.8	49.26	38.52
$2w = 79.06°$		$2w = 82.1°$		$2w = 84.4°$		$2w = 87.78°$	
$p = .191$		$p = .139$		$p = .098$		$p = .039$	

The chief difficulty encountered in making these determinations was the lack of perfect uniformity in the emitting surface. The uranium glass, being rendered self luminous by the beam from the lantern, could not have entire uniformity over its surface unless the illuminating beam was uniform in intensity, which was not the case. The images corresponded to points on the surface not more than 2 mm. apart, and yet it was found that the equality of the images could be sometimes disturbed by directing the instrument toward a new portion of the field. As great care as possible was taken to direct the polarimeter toward such portions of the field as appeared to have a uniform illumination, and it is not thought that the error due to this cause could have been great.

Phosphorescent bodies were also examined for polarization, but the light emitted by such bodies is so weak that no definite results were obtained.

X.

Application of Fresnel's Formulæ for Vitreous Reflection.

The main object of this research being to determine whether or not polarization by emission could be experimentally proven to be a phenomenon of refraction, Fresnel's laws for reflection and refraction, which have been shown by many experiments to accurately represent the facts, were now applied to the determination of the amounts of polarization which should be produced by single refraction of light passing through the boundary surface between uranium glass and air. In order to apply these laws it is necessary to assume that all of the light emitted by the uranium glass, whether coming *from the surface molecules or from the interior layers*, has undergone the process of refraction—an assumption not contained in Arago's explanation of the cause of the phenomenon.

Taking the intensity of the incident ray as unity, Fresnel's formulæ give for the intensities of the reflected and refracted rays, when the incident beam is plane polarized in the plane of incidence,

$$\text{reflected ray} = r_1 = \frac{\sin^2(\alpha - \beta)}{\sin^2(\alpha + \beta)}$$

$$\text{refracted ray} = r_1' = \frac{4\cos^2\alpha\sin^2\beta}{\sin^2(\alpha + \beta)}$$

α being the angle of incidence and β the angle of refraction.

For a ray plane polarized in a plane perpendicular to the plane of incidence

$$\text{reflected ray} = r_2 = \frac{\tan^2(\alpha - \beta)}{\tan^2(\alpha + \beta)}$$

$$\text{refracted ray} = r_2' = \frac{4\cos^2\alpha\sin^2\beta}{\sin^2(\alpha + \beta)\cos^2(\alpha - \beta)}$$

Since ordinary light may be considered as composed of two equal plane polarized beams, polarized in planes at right angles to each other, the amount of polarization in a beam of natural light which has undergone single refraction is

$$\frac{\frac{1}{2} r_2' - \frac{1}{2} r_1'}{\frac{1}{2} r_2' + \frac{1}{2} r_1'} = \frac{r_2' - r_1'}{r_2' + r_1'} = \frac{\frac{1}{\cos^2(\alpha-\beta)} - 1}{\frac{1}{\cos^2(\alpha+\beta)} + 1} = \frac{1-\cos^2(\alpha-\beta)}{1+\cos^2(\alpha+\beta)} = p$$

The only unknown quantity in this formula is the angle β. In order to determine β for any given angle it was only necessary to determine the index of refraction of the uranium glass.

The glass being of considerable thickness the microscope method was the one best adapted to this determination. d being the thickness of the glass, and a the change in focus due to the introduction of the glass between the object o and the objective, the index u is given by the formula (see Kohlrausch Praktische Physik, p. 151).

$$u = \frac{d}{d-a} = \frac{326\text{ mm}}{326\text{ mm}-110\text{mm}} = 1.51 = \frac{\sin \alpha}{\sin \beta}$$

The substitution of the various values of β, thus found, in the formula for p gave the following values :

α	β	p
87° 30′	41° 25′	.351
85°	41° 17′	.315
80°	40° 42′	.251
75°	39° 46′	.206
70°	38° 29′	.153
65°	36° 53′	.125
50°	30° 29′	058

The correspondence between the results given by experiment and those given by this calculation from Fresnel's formulæ was unexpected. The experiments were completed more than a month before any calculations were made, so that I had no idea at the time of making the experiments what would be the nature of the results given by calculation.

The differences between the two sets of values are hardly greater than the possible errors of observation. The differences at 65° and 50° are quite large, but might have been due to the lack of perfect uniformity in the luminous surfaces. On the whole, the agreement between the two sets of results indicates strongly that in the case of uranium glass, at least, the phenomenon is one of simple refraction at the surface; but that the WHOLE *of the emitted light undergoes the refraction process.*

XI.

Experiments upon Platinum.

It is evident that no such comparisons as those just made for uranium glass could be made for the case of incandescent metals, unless, in the first place, the surface experimented upon could be assumed to be a perfectly definite, non-diffusing surface. The chief source of difficulty in the work upon platiuum was to fulfill this condition.

It was found, after considerable work had been done upon platinum, that continual heating roughened the surface to a slight degree, and changed the amount of polarization. The results of several sets of laborious observations upon platinum were discarded altogether, because they were found to be erroneous from this cause. However, the change is so gradual that a well polished platinum surface may be heated to incandescence for several minutes without showing any perceptible change in character. The rapidity of the change could be delicately observed by viewing the surface at a large angle of incidence by means of the polarimeter. For a period of two or three minutes no change was perceptible in the equality of the images, but for much longer periods of heating the slow blistering of the surface began to be manifest in the disturbance of the equality of the images. Hence, in order to avoid this error, the surface of the platinum was carefully polished with rouge after every set of readings for a given angle.

A second slight source of error in the observations upon platinum was the lack of exact horizontality in the surface examined. The attempt was made to avoid this error by rotating the instrument through 90° according to the suggestion of Cornu. This brought the extraordinary image either above or below the ordinary; hence, when the angle of emergence was very large, the two images corresponded to points on the surface at a considerable distance from each other, as shown in the figure.

This introduced the likelihood of a much greater error than that due to a slight error in horizontality. The incandescent platinum was therefore rendered as nearly horizontal as possible by comparison with carefully levelled reference planes placed in the immediate vicinity. The adjustment could thus be easily made to within one degree.

In all of the following experiments, sheets of rolled platinum .06 mm. in thickness were heated to a white heat by means of a Bunsen burner, care being taken to prevent light from any other sources from vitiating the results. The observations are here given in full.

80°		70°		60°	
Left.	Right.	Left.	Right.	Left.	Right.
23.1	12.0	30.2	20.7	36.9	24.5
21.4	11.5	32.2	21.0	36.8	26.1
22.5	11.3	32.1	21.2	35.0	25.0
22.3	10.9	31.0	20.5	37.0	25.4
23.2	11.4	32.1	21.3	35.6	25.5
				35.5	25.4
22.5	11.49	31.52	20.94	36.05	25.2
$2w = 34°$		$2w = 52.4$		$2w = 61.25°$	
$p = .829$		$p = .610$		$p = .481$	

50°		40°		30°	
Left.	Right.	Left.	Right.	Left.	Right.
40.0	29.7	45.6	35.0	47.6	38.0
39.1	29.0	45.5	33.3	47.5	36.3
41.2	29.3	44.4	34.2	47.2	36.2
39.4	28.5	43.8	34.6	47.8	37.1
41.0	29.6	44.4	34.5	48.0	36.0
40.14	29.2	44.74	34.3	47.62	36.72
$2w = 69.34°$		$2w = 79°$		$2w = 84.34$	
$p = .349$		$p = .191$		$p = .099$	

XII.

Application of Cauchy's Formulæ for Metallic Reflection to the Case of Platinum.

Fresnels formulæ for reflection rest upon the hypothesis that the time required in the process of reflection is infinitesimal in comparison with a wave period, and hence that the phase of vibration of the reflected ray is either the same as that of the incident ray, or else differs from it by the quantity π. It follows from this assumption that the reflected ray is plane polarized, if the incident ray is plane polarized.

When the reflection takes place at the boundary surface between air and a metal, experiment shows this assumption to be incorrect, and hence Fresnel's formulæ become inapplicable.

If the phenomenon here considered be due to reflection, the laws for reflection which apply to the boundary surface between platinum and air are, of course, the laws to apply to the determination of the amounts of polarization which ought to be caused by a single refraction at this boundary.

The application of Fresnel's laws of vitreous reflection requires, as has be seen, the determination of but one constant, the index of refraction, or the ratio of the velocities of propagation of light in the two media. Cauchy extended these laws so as to cover the case of metallic reflection by introducing another constant which he calls the co-efficient of extinction. The constant corresponding to the index of refraction is, as in the case of transparent bodies, the tangent of the angle of maximum polarization. The co-efficient of extinction is a constant depending upon the opacity of the body, and is found from the ratio between the amplitudes, after reflection, of two equal beams polarized respectively perpendicular and parallel to the plane of incidence, and reflected at the angle of maximum polarization. This ratio is evidently the tangent of the azimuth of re-established plane polarization, when the incident beam is polarized in a plane making an angle of 45° with the plane of incidence, plane polarization being re-established after reflection by means of a quarter-wave plate or a Babinet compensator.

This angle may be determined by experiment. Thus the two constants of metallic reflection are, 1, the angle of maximum polarization, and 2, the azimuth of re-established plane polarization at this angle. According to the theory of Cauchy, these two constants being known, the intensity of a beam reflected at any angle may be calculated.

The complete explanation of Cauchy's theory and the deduction of Cauchy's formulæ were given by Eisenlohr in 1858. (see Pogg. Ann. 104, p. 368).

The final forms of the formulæ given by Eisenlohr are

$$K^2 = \tan\,(f - 45^\circ) \qquad K'^2 = \tan\,(g - 45^\circ \quad (1)$$

in which K^2 is the intensity of the reflected beam when the incident beam is polarized in the plane of incidence, K'^2 the intensity when the incident beam is polarized in the plane perpendicular to the plane of incidence, and f and g are variables given by the equations

$$\left.\begin{aligned} \cot f &= \cos\,(e + u)\,\sin\,\left(2 \arctan \frac{c\,\Theta}{\cos a}\right) \\ \cot g &= \cos\,(e - u)\,\sin\,\left(2 \arctan \frac{\cos a}{c\,\Theta}\right) \end{aligned}\right\} \quad (2)$$

in which u and c are variables determined by the relations

$$\left.\begin{aligned} \cot(2u+e) &= \cot e \cos\left(2 \arctan \frac{\sin \alpha}{\theta}\right) \\ c^2 &= \frac{\sin 2e}{\sin(2u+2e)} \end{aligned}\right\} \quad (3)$$

in which α is the angle of incidence, and ε and ϑ are given by the final formulæ

$$\left.\begin{aligned} \sin 2e &= \tan^2 A \sin(4H - 2e) \\ \vartheta &= \sin A \sqrt{\frac{\sin 4H}{\sin(4H-2e)}} \end{aligned}\right\} \quad (4)$$

in which A is the angle of maximum polarization called the "principle angle of incidence," and H is the azimuth of re-established plane polarization when the incident beam is polarized in azimuth 45°. H is called the "prime azimuth." The forms here given for ε and ϑ are due to Jochman (see Pogg. Ann. CXXXVI., p. 8561). These formulæ, first published by Cauchy in 1839, were shown by Jamin, by an elaborate series of measurements, to very closely represent the facts of reflection from metallic surfaces. The prime angles of incidence and the prime azimuths for all the common metals and for the different Fraunhofer lines were determined by Quincke in '74 (see Phil Mag. XLVII., p 221).

Now, in order to apply these formulæ to calculations similar to those which have already been made with Fresnel's formulæ upon uranium glass, it was necessary to assume, as before, that the whole of the light emitted had undergone refraction, and it was also necessary to know the two optical constants for platinum at the temperature of incandescence. These constants could not be determined. However, in a number of experiments made by W. R. Grove (see Phil. Mag. (4) 17, p. 177) upon the reflection of light from incandescent platinum, he was unable to detect any change in the reflecting properties of the platinum due to the fact of incandescence. Plane polarized light being reflected from the cold surface, the plane of polarization of the reflected beam was not affected by heating the platinum to the incandescent temperature. These experiments were not performed with delicate apparatus, yet they give reason to assume that the optical constants of platinum are not greatly altered by temperature.

Assuming, then, the values of A and H given by Quincke for the sodium line, the calculations of the amount of polarization in the emitted beam were made for all the angles of emergence upon which experiments had been made. These calculations were made as follows :

Quincke's values for the D line are

$$A = 77^\circ\ 8' \qquad \qquad \varepsilon = 64^\circ\ 22'$$
$$H = 32^\circ\ 46' \quad \text{Formulæ (4) give} \quad \log\theta = .62276$$

Then for $\alpha = 80^\circ$ formulæ (3) (2) and (1) give

$$K^2 = .9348 \qquad K'^2 = .4013$$

Assuming now the incident beam to have had an intensity unity, the emitted beam polarized in the plane of emergence would have an intensity

$$1 - K'^2 = .0652$$

And the beam polarized in the plane perpendicular to the plane of emergence an intensity

$$1 - K'^2 = .5987$$

Therefore the degree of polarization $= p = \frac{.5987 - .0652}{.5987 + .0652} = .834.$

The complete results of the calculations for the platinum are as follows :

α	K^2	K'^2	$1-K^2$	$1-K'^2$	p
80°	.9348	.4013	.0652	.5987	.834
70°	.8757	.4044	.1243	.5957	.655
60°	.8234	.4813	.1766	.5187	.492
50°	.7782	.5483	.2218	.4517	.341
40°	.7409	.5981	.2591	.4019	.216
30°	.7115	.6330	.2885	.3670	.117

Considering the number of assumptions which have been made, the correspondence between these quantities and those given by experiment is altogether remarkable, and points with as much certainty as the work upon uranium glass to the conclusion that the phenomenon is simply one of refraction.

XIII.

Difference in Color of Images.

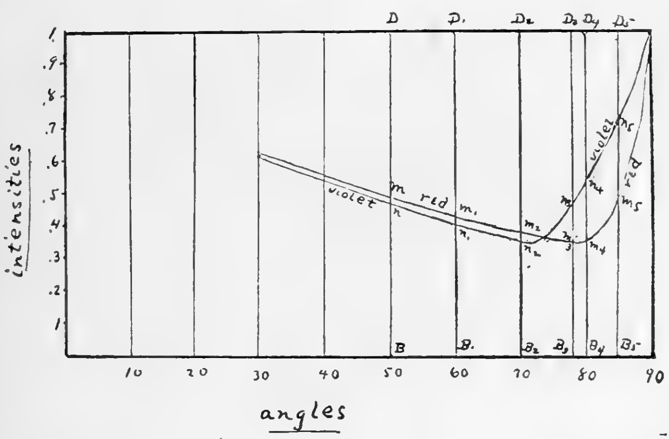
In the course of these observations upon platinum, another at first unaccountable phenomenon was noticed. At large angles of emergence the color in the two images was notably different. The feeble image, *i. e.*, the one corresponding to vibration perpendicular to the plane of emergence seemed for large angles to be deficient in red light, while the other image was abnormally red.

If we assume the phenomenon to be due to reflection and refraction, this appearance is readly explained by a referenee to Quincke's values for the angles of maximum polarization for the different Fraunhofer lines.

This angle for the line C, Quincke gives as 78° 28′, and for the line G his value is 73° 39′.

Now if a is the amplitude of vibration in the reflected ray when the incident beam is polarized in the plane of incidence, and a' the amplitude when the plane of polarization of the incident beam is perpendicular to the plane of incidence the angle of maximum polarization will be reached when $\frac{a^2 - a'^2}{a^2 + a'^2}$ is a maximum, *i. e.*, when $\frac{a'}{a}$ is a minimum.

The experiments of Jamin show that this angle coincides, at least very nearly, with the angle for which a' is a minimum; a



conclusion which one would expect without the aid of experiment. Hence the angle 78° 28′ is that angle for which the component of the *reflected* vibration parallel to the plane of incidence is a minimum for the case of *red* light, and the component of the *emitted* vibration in the same plane is a maximum. On the other hand the angle of maximum emission of *violet* light in this plane occurred at 73° 39′. Accordingly it is evident that red light predominates in the beam emitted at the angle 78° 28′, and violet in the beam emitted at 73° 39′. The approximate ratio between the two colors for any angle is shown in the diagram. It is evident that light emitted at any angle larger than 75° will be predominantly red At the same time the shape of the curves accounts for the lack of any noticeable predominance of violet in the neighborhood of 73° 39′.

The figure shows the curves of intensities of the reflected components of vibration parallel to the plane of incidence as roughly plotted from the values given above. The lines M D, M_1 D_1, etc., represent the intensities of the emitted red vibrations in this plane for various angles; while the lines N D, N_1 D_1, etc., represent the intensities of the emitted violet vibrations for the same incidences. The lines N M, N_1 M_1, etc., are the measure of predominance of red over violet, or *vice versa*. The steepness of the curves at points corresponding to angles greater than the angle of maximum polarization and the lack of steepness at points corresponding to angles less than the angle of maximum polarization are evidently the cause of the marked predominance of red at large angles and the lack of noticeable predominance of violet at any angles. This characteristic of the curves follows from the fact that the points of maximum polarization correspond to very large angles.

XIV.

Experiments upon Silver.

Owing to the great kindness of Mr. Herbert G. Torrey, Assayer of the U. S. Assay Office, I was next able to make a series of observations upon molten silver. These experiments were the most satisfactory of any which were made in the course of the research. All of the sources of error which had existed in preceding cases were here eliminated. The surface was perfectly defined, it was accurately horizontal, and there were no variations in intensity from point to point. The results of the experiments are given in full.

30°		35°		40°		45°	
Left.	Right.	Left.	Right.	Left.	Right.	Left.	Right.
46.0	36.0	44.5	33.4	43.3	31.7	42.0	30.5
47.2	36.0	45.0	33.7	42.8	32.5	42.0	31.0
46.5	35.0	44.5	34.0	43.3	32.0	41.1	31.3
46.3	35.0	45.0	34.0	43.5	32.0	42.5	30.5
46.5	35.5						
46.5	35.5	44.75	33.8	43.72	32.05	41.9	30.8
$2w = .82°$		$2w = 78.55°$		$2w = 75.27°$		$2w = 72.7$	
$p = .139$		$p = .189$		$p = .254$		$p = .297$	

50°		55°		60°		65°	
Left.	Right.	Left.	Right.	Left.	Right.	Left.	Right.
40.6	28.5	38.0	27.0	34.7	24.1	32.0	21.0
40.0	29.0	38.3	27.5	35.0	24.0	32.5	21.5
40.0	29.8	37.5	27.1	34.0	24.1	32.6	21.0
40.5	29.1	37.5	26.3	35.4	23.8	32.5	20.5
40.0	28.8	38.0	26.5	35.7	24.0	32.5	21.5
				34.5	24.0		
40.2	29.04	37.8	26.8	34.9	24.0	32.4	21.3
$2w = 69.24°$		$2w = 64.6°$		$2w = 58.9°$		$2w = 53.7°$	
$p = .354$		$p = .429$		$p = .517$		$p = .592$	

70°		75°		80°	
Left.	Right.	Left.	Right.	Left.	Right.
30.0	20.0	27.0	16.5	24.1	13.5
30.0	19.5	27.0	16.5	24.1	13.5
29.6	19.9	27.0	16.5	24.2	14.0
30.0	20.4	26.5	16.1	23.9	13.7
30.5	19.5	27.0	16.4	24.0	13.9
		26.5	15.5		
30.0	19.9	26.8	16.25	24.1	13.7
$2w = 49.9°$		$2w = 43.05$		$2w = 37.8$	
$p = .644$		$p = .731$		$p = .789$	

All of the previous observations had been subject to errors of unknown magnitude, aside from the errors of observation; and the results, while agreeing very closely with the calculated values for some angles, differed from them by considerable amounts at others. For example, the agreement for platinum at 80° was very close, while at 70° the difference was as large as .045. Similarly for uranium glass, the difference at 50° and 65° was quite large. Hence I did not consider the results given by the experiments upon uranium glass and platinum altogether trustworthy as accurate quantitative measurements. The experiments upon silver, however, were free from all possible error so far as I was able to discover, except the observational error. Mention has already been made of the fact that Violle had previously made a number of determinations of the same general nature upon silver. His results do not agree very closely with those given above, being uniformly larger. I am altogether unable to account for the uniformity in the excess of his values over those given by these experiments. His results are here inserted for the sake of comparison.

Angle.	Violle.	Millikan.
30	.168	.139
50	.383	.354
60	.546	.517
65	.630	.592
70	.708	.644
75	.770	.731
80	.826	.789

The application of Cauchy's formulæ to silver was made in the same way as in the case of platinum. For polished silver Quincke gives for the D. line,

Prime angle of Incidence, $A = 72° \ 10'$,
Prime Azimuth, $H = 41° \ 40'$,
Formulæ (4) give, $\begin{cases} e = 82° \ 34.3', \\ \log. \theta = .4480. \end{cases}$

Formulæ (3) (2) and (1) then give

a	K^2	K'^2	$1-K^2$	$1-K'^2$	p.
80	.9735	.8037	.0265	.1963	.762
75	.9606	.7628	.0394	.2372	.716
70	.9482	.7510	.0518	.2489	.655
65	.9361	.7540	.0639	.2460	.588
60	.9250	.7632	.0750	.2368	.519
55	.9136	.7740	.0864	.2260	.446
50	.9033	.7869	.0967	.2131	.376
45	.8937	.7985	.1063	.2015	.309
40	.8847	.8093	.1153	.1907	.246
35	.8767	.8187	.1233	.1813	.190
30	.8695	.8268	.1305	.1732	.140

It will be noticed that the agreement between these quantities p and those given by my experiments is closer than for either the platinum or the uranium glass; the largest difference being at 80°, where it amounts to .027.

XV.

Experiments upon Gold and Iron.

Through the kindness again of Mr. Torrey and the Superintendent of the Sub-Treasury, I was permitted to make observations upon a pot of molten gold; but accuracy of work was impossible on account of (1) the rapidity with which I was obliged to work (2); the lack of quiescence of the liquid surface; (3) the impossibility of excluding other light from the surface, and (4) the rapidity of oxidization of the molten gold. The results were therefore altogether untrustworthy as quantitative measurements. Hence no attempt was made to compare them with results given by Cauchy's formulae.

Molten iron was also made the subject of similar observations with equally unsatisfactory results.

XVI.

Discussion of Results.

All of the comparisons made between experimental determinations and calculated values are condensed in the following tables.

Uranium Glass.

Angle.	p. obs.	p. calc.	differ'nce.
87½	.358	.351	.007
85	.293	.315	—.022
80	.245	.251	—.006
75	.191	.206	—.015
70	.139	.153	—.014
65	.098	.125	—.027
50	.039	.058	—.019

Platinum.

Angle.	p. obs.	p. calc.	differ'nce.
80	.829	.834	—.005
70	.610	.655	—.045
60	.481	.492	—.011
50	.349	.341	+.008
40	.191	.216	—.025
30	.099	.117	—.018

Silver.

Angle.	p. obs.	p. calc.	differ'nce.
80	.789	.762	+.027
75	.731	.716	+.015
70	.644	.655	—.011
65	.592	.588	+.004
60	.517	.519	—.002
55	.429	.446	—.017
50	.354	.376	—.022
45	.297	.309	—.012
40	.254	.246	+.008
35	.189	.190	—.001
30	.139	.140	—.001

In view of the general agreement between the observed and calculated values, and in view of the further fact of the coloration of the images at large angles, so beautifully accounted for by the reflection theory, it may be considered that the phenomenon of polarization of light by emission has thus been quantitatively proven to be a phenomenon of reflection and refraction.

It will be remembered that the apparently insuperable objection to the explanation which Arago offered was that that explanation attributed to all of the surface molecules the property of emitting natural light, and gave as the entire cause of the polarization, the refraction of light which works its way up from a certain depth beneath the surface.

The above calculations were all made upon the assumption that *all* of the light emitted by the glowing body had undergone a refraction. Considering the closeness of agreement between the calculated and observed values, it is difficult to escape the conclusion that this assumption is correct, and that *no* particles whatever of the incandescent solid send out into the air natural light, save in the case in which the angle of emergence is zero. This simply means that all of the particles of the light emitting body, *including* the so-called surface layers, lie within the denser medium, and beneath the plane at which reflection and refraction take place. This relieves the refraction theory of the causes of the phenomenon of its greatest difficulty: viz., the difficulty of conceiving that, in the case of an exceedingly opague body like platinum, the uppermost molecules send out but a very small proportion of the whole light emitted. If we follow the explanation of Arago and Verdet we are obliged by the results of this research to conclude that the emitted light originates almost entirely in molecules other than those of the uppermost layer. On the contrary it seems much more reasonable to assume that, in the case of such a body as platinum, the light emitted is due mainly to this topmost layer, but that the reflection process takes place entirely above the platinum.

Quincke has shown that when light from an external source is reflected at the surface of a metal the reflection does not take place in the geometrical plane between the two media, but rather takes place in the metal itself, the vibration penetrating for a certain depth into the denser medium. The converse is also doubtless true that the vibration originating in the metal is not reflected instantaneously at the surface of the rarer medium, but is reflected in the layer of air of finite thickness which borders upon the metal. Thus all light originating in the platinum, whether in the surface layer or the sub-surface layers, must undergo the process of reflection and refraction before it can emerge into the air.

Lastly, the calculated values were all obtained under the assumption that the optical constants of the metals are the same for high temperatures as for low; that is, that the reflecting properties of an incandescent metallic surface are precisely the same as the reflecting properties of a cold metallic surface. The closeness of agreement between the results given by this assumption and the facts as determined by experiment seems to warrant the conclusion, that the change in the optical properties of metals due to incandescence is *exceedingly slight*; a conclusion to which the somewhat inexact experiments of Grove upon the reflecting properties of incandescent platinum would also lead.

In conclusion, I will add that this investigation was suggested to me by Professor rood, and I wish here to express my great indebtedness to him and to Professor Hallock, and also to Professor A. A. Michelson, of Chicago University, for aid furnished during its progress. I am also under obligations to Herbert G. Torrey, Esq., Assayer of the U. S. Assay Office, who most kindly placed at my disposal large masses of molten gold and silver.

R. A. Millikan.

Stated Meeting.

April 8th.

After a brief notice by Pres. Rees regarding the lecture to be held in connection with the American Museum of Natural History by Mr. Ives, on "Color Photography," the Biological Section organized, with Dr. Britton in the chair and an attendance of about one hundred.

Prof. E. B. Wilson delivered the lecture of the evening, "The Fertilization and Early Development of the Ovum." A brief historical review of the subject was given, followed by a discussion of the results of his own researches on *Toxopneustes.* A series of lantern slides, fifty in number, from photo-micrographs taken by Dr. Edward Leaming, was finally used to illustrate the fertilization phenomena. The following stages were prominently shown: The entrance of the sperm cell, its rotation, the origin of the archoplasm from the "middle piece," the nearing of the pronuclei, the maturation of the eggs, the spindle for the extension of the first polar body, karyokinesis.

Before adjournment Prof. Kemp read by title two papers: G. F. Matthew, "New form of Graptolites from the Cambrian;" H. P. Cushing, "Petrographical Notes on Rocks from Alaska."

H. P. Cushing, Petrographical Notes on some Alaska Rocks.

J. F. Kemp,
Rec. Sec. Biol. Sect.

Stated Meeting.

April 15th, 1895.

The Academy met with Vice-President Stevenson in the chair, and twenty-five members present. The minutes of the previous meeting were read and approved. The following names were presented for resident membership: H. Deforest Earle, Francis Lynde Stetson, and were referred to the Council.

The Secretary read the following memorial of the late Mr. J. H. Redfield.

The Committee appointed by the Academy to prepare a minute relative to the death of Mr. John H. Redfield respectfully submits the following:

The Academy has learned with sorrow of the death of Mr. John H. Redfield, at his home in Philadelphia, on February 27th, 1895.

Mr. Redfield was one of the earliest members of the Lyceum of Natural History, having been elected in 1836. During his years of residence in New York he was most active in furthering the work of the Lyceum, a frequent contributor to its preceedings, and the author of several conchological papers which were printed in its Annals. In connection with his father, Mr. W. C. Redfield, he published, in Vol. IV. of the Annals, the first description of fossil fishes from the Mesozoic rocks of America, proposing the name of the genus *Catopterus*, and its type species *C. gracilis*, beside some others, for specimens from the Triassic beds at Durham, Conn. He was thus the pioneer in this important branch of American palæontology. He held the office of Recording Secretary of the Lyceum in the years 1837–8, and of Corresponding Secretary for the entire period from 1839 to 1860. After his removal to Philadelphia he did not lose his interest in the Lyceum, but continued his relations with it as a corresponding member, not only through the whole period of its existence under the old name, but also when the organization was changed and enlarged into the Academy and down to the time of his death. When the memorial volume was published, in 1887, Mr. Redfield furnished a large amount of most valuable data and reminiscences, which are embodied and acknowledged at many points in the book.

Although personally acquainted with but few of our present members, many have known of his great work in connection with the Academy of Natural Sciences in Philadelphia, and by reason of this, and his early prominence in our own society, he has had our profound respect and grateful esteem. It is therefore,

Resolved, That it is the sense of the Academy that in the death of Mr. John H. Redfield, American Science has lost a critical and enthusiastic student, a liberal patron, and a devoted friend; and the Academy a co-laborer who greatly aided in its early period of organization, as an officer and a scientific investigator, and who was almost the last to connect its present membership with the generation of its founders and pioneers.

N. L. BRITTON,
D. S. MARTIN,
A. A. JULIEN,
Committee.

The Section of Geology and Mineralogy next organized, and listened to the paper of the evening by Dr. J. L. Wortmann, on the "White River Miocene Deposits." The paper was illustrated by beautiful lantern views, and at the close a vote of thanks was given the speaker.

J. F. KEMP,
Rec. Sec.

THE EFFUSIVE AND DYKE ROCKS NEAR ST. JOHN, N. B.

W. D. MATTHEW.

Read by title, March 17th, 1895.

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LITERATURE.

1. Reports of the Geological Survey of the Province of New Brunswick, 1839–43, by Abraham Gesner.

2. Observations on the Geology of Southern New Brunswick, by L. W. Bailey, G. F. Matthew and C. F. Hartt.

3. On the Azoic and Palaeozoic Rocks of Southern New Brunswick, by G. F. Matthew. Quar. Jour. Geol. Soc. XXI., 422.

4. Remarks on the Age and Relations of the Metamorphic Rocks of New Brunswick and Maine, by Geo. F. Matthew and L. W. Bailey. Proc. Am. Ass. Adv. Sci. 1869, 179.

5. Preliminary Report on the Geology of Southern New Brunswick, L. W. Bailey and G. F. Matthew. Can. Geol. Sur. Rep. 1870–1, p. 13.

6. Summary of Geological Observations in Southern New Brunswick, by L. W. Bailey and G. F. Matthew. Can. Geol. Sur. Rep. 1874–5, p. 84.

7. Report of Geological Observations in Southern New Brunswick, by L. W. Bailey, G. F. Matthew and R. W. Ells. Can. Geol. Sur. Rep. 1875–6, p. 348.

8. Report on the Pre-Silurian (Huronian) and Cambrian or Primordial Silurian Rocks of Southern New Brunswick, by L. W. Bailey. Can. Geol. Sur. Rep. 1877–8, p. 1–34 DD.

9. Report on the Upper Silurian and Kingston (Huronian) of Southern New Brunswick, by G. F. Matthew. Ib. p. 1–6 E.

10. Report on the Geology of Southern New Brunswick, embracing the counties of Charlotte, Sunbury, Queens, Kings, St. John and Albert, by L. W. Bailey, G. F. Matthew and R. W. Ells. Can. Geol. Sur. Rep. 1878–9, p. 1–26 D.

11. On the Progress of Geological Investigation in New Brunswick 1870–1880, by L. W. Bailey. Proc. Am. Ass. Adv. Sci. 1880, p. 415.

12. On the Progress of Geological Investigation in New Brunswick. Trans. Roy. Soc. Can. 1889, VII., Sec. 4, 3–17.

13. Cambrian Organisms in Acadia, by G. F. Matthew in Trans. Roy. Soc. Can. 1889, Sec. 4, p. 135.

14. Correlation Papers, Archæan and Algonkian, by C. R. Van Hise. U. S. Geol. Sur. Bull. 86. 1892.

15. Matthew, W. D., Intrusive Rocks near St. John, N. B. Trans. N. Y. Ac. Sci. XIII., 185. 1894.

16. Outlets of the St. John River, by G. F. Matthew. Nat. Hist. Soc. New Bruns. Bull. XII., 1895.

The present paper is a continuation of a petrographic study of the igneous rocks near St. John, N. B. The intrusive rocks in the immediate neighborhood of the city have already been discussed;* it remains to describe the surface volcanics and dykes, and to add some notes as to the further extension of the intrusives.

Pre-Cambrian volcanic rocks are known to exist at various points along the flanks of the metamorphic belt of eastern North America. Although more or less clearly recognized as such in many of the earlier surveys, their certain determinations could usually be made only by the aid of thin sections, and accordingly it is only within the last few years that their exact character has been definitely known. The late Dr. Geo. H. Williams, in an article in the Journal of Geology,† has called attention to their wide distribution and importance, and to their close resemblance to modern effusives, except where altered by metamorphism. Dr. Williams gives a very full and complete summary of their occurrence in Newfoundland, Nova Scotia and New Brunswick, the eastern townships of Quebec, in Maine, New Hampshire and eastern Massachusetts, in the South Mountain of Pennsylvania and Maryland, and along the Blue Ridge as far south as Georgia. There is, however, a great dearth of petrographic descriptions of these rocks, most of the determination having been made in the field only. Besides the well known

* Trans. N. Y. Acad. Sci. XIII., 185.

† Jour. Geol. II., 1.

work of Dr. Williams* and Miss Bascom† on the South Mountain volcanics, and the studies of Wadsworth,‡ Diller § and Sears || in the Boston Basin, the only descriptions of ancient effusive rocks from the eastern coast of which the writer knows are the recent article of Dr. Bayley ¶ on the spherulitic felsites from Vinal Haven, Me., and a few descriptions of porphyries from the eastern townships by Dr. Adams**. There is, no doubt, other work of the kind in preparation, and quite probably other published descriptions exist, which have escaped this review; still the scantiness of petrographic descriptions of these early volcanics of the east coast, in comparison with those from other parts of the United States, is rather remarkable.

In Southern New Brunswick the so-called Huronian has been believed from the first to be in large part volcanic, and was so described in the reports of the different surveys.

The first systematic survey was made by Dr. Abraham Gesner for the Provincial Government in 1838–42, its results being published in five reports dated 1839–43, inclusive. Dr. Gesner was greatly impressed with the important part which had been played in Southern New Brunswick by volcanic forces, which, however, he was inclined to over-rate, ascribing to them many of the effects due to erosion. Speaking of the southern part of the province he says:

"At the southeastern base of this elevated region" (the granite area which divides Southern from Central New Brunswick) "the slates and limestones of the transition series, and the sandstones and conglomerates of the secondary formations, are placed in their usual order of succession, wherever they have not been broken up and buried by extensive eruptions of volcanic matter. All these rocks have been penetrated by large and numerous dikes of trap, basalt and pophyry (*sic*), and the surface of the country with all the islands in the Passamaquoddy Bay exhibit the clearest evidences of having been the theatre of violent earthquakes and intense volcanic action."††

Although some of the massive rocks which Dr. Gesner believed igneous have been since shown to be of sedimentary origin, yet his estimate of the importance of eruptive rocks in this

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*Amer. Jour. Sci. XLIV., 482.

†Jour. Geol., I.

‡ Bull. Mus. Comp. Zöol. Harv., V., 275; Proc. Bost. Soc. Nat. Hist., XXI., 288.

§ Bull. Mus. Comp. Zoöl. Harv., VII., 165.

|| Bull. Mus. Comp. Zöol. Harv., XVI., No. 9; Bull. Essex Inst., XXVI., 118 etc.

¶ Geol. Soc. Amer., Baltimore Meeting, Dec., 1894.

** Can. Geol. Sur. Report of 1839, p. 12.

†† Report of 1839, p. 12.

part of the Province still holds good. But it is evident from the tone of his writing that he considered the volcanic outbursts as of far later date than that now assigned to them, for he connects these disturbances with recorded earthquakes and changes of level in New Brunswick within historic times, and even pictures a number of supposed volcanic cones near Great Salmon River, east of Quaco.*

In the Dominion Government Survey Reports, Dr. L. W. Bailey and G. F. Matthew recognize the existence of great amounts of volcanic ash, as well as massive lavas, porphyritic and vesicular. But the greater part of the series, consisting of fine-grained rocks denoted as *felsite* and *petrosilex*, remained to the last of doubtful origin, with an apparent tendency in Dr. Bailey's later report (1877–8), written after a most careful and thorough study of the volcanic hills, to consider them as largely sedimentary rocks, though formed under special conditions of deposition; † while Dr. Ells ‡ considers them as volcanic. In his latest paper bearing on this subject § Dr. Bailey points out the need of microscopic sections of these rocks, both to make sure of their character and perhaps to determine also whether certain members are of pre-Cambrian age or are identical with very similar rocks of later origin. He summarizes the character and relations of the pre-Cambrian rocks as follows:

"Among these Archæan rocks at least two great groups of sediments are to be distinguished, which, in a general way, bear many features of resemblance to those which in other parts of Canada are known as the Laurentian and Huronian systems. At the same time it is impossible . . . not to see that . . . there are equally striking differences, . . . especially seen in the greater proportionate amount of distinctly stratified rocks, such as slates and quartzites, in the comparative absence of coarsely crystalline deposits of crystalline minerals and ore beds, and in the much greater regularity and uniformity of the whole . . . Another desideratum in connection with these two ancient systems is a better understanding of their time relations to each other, for though no doubt is entertained by the author as to the fact that the felsitic and schistose rocks referred to the Huronian are more recent than the granitoid and gneissic rocks and the great belts of crystalline limestone which have been regarded as Laurentian, a contrary view has

* Report of 1840, p. 21.

† Can. Geol. Sur. Rep. 1877–8, p. 4, D. D. In a foot-note at this page, Dr. Selwyn compares this series to the ancient volcanic rocks of England and Wales, with which he believes they are identical in origin.

‡ Ib., p. 3 D.

§ Trans. Roy. Soc. Can., 1889, Vol. VII., Sec. 4, p. 3.

been taken by others; while neither has any satisfactory contact of the two formations been observed, nor an instance in which the conglomerates of the one are unquestionably made up of material derived from the other." *

Collections made during the past three summers and studied by the aid of the microscope have amply confirmed the views held as to the volcanic origin of the greater part of the "Huronian." It will be seen that a considerable variety of igneous rocks is represented, including lavas and ash rocks once precisely like those of modern times and not greatly altered by metamorphism. Many of the fine grained felsites and much of the petrosilex, however, cannot be certainly determined, even with the aid of thin sections; but judging from the almost complete absence among them of distinctly recognizable sediments, it is probable *that the greater part of the doubtful ones should be considered as altered ashes or tuffs.*

The pre-Cambrian of Southern New Brunswick falls naturally into two great divisions: a lower one composed of gneisses, limestones, quartzites and various schistose rocks, usually highly crystalline, but of distinctly sedimentary character; and an upper one composed chiefly of volcanic products, fading out above into more normal sedimentary beds which are as a rule much less altered than those of the lower series. The lower group has been compared to the Laurentian; the upper has been called Huronian; but both these names are dropped in the later Survey Reports and replaced by numbers for the different groups. In the present paper they may be occasionally used as indicating this two-fold division, but not implying any correlation in the present restricted sense of the terms.

The Laurentian series includes divisions 1 and 2 of the later reports; the first being granitic gneiss and granite, which is, near St. John at least, intrusive in Division 2, and may be placed provisionally between it and the volcanic series. Division 2 is clearly sedimentary, and shows a varying amount of regional metamorphism, being at times comparatively little altered.

The upper series or "Huronian" includes at least three subgroups. These are:

1. *Coldbrook* (Div. 3). This is composed almost entirely of volcanic rocks—lavas, ashes and tuffs. The most abundant types of rock are felsites and "petrosilex" (fine-grained, flinty quartz-felsite), often porphyritic and accompanied by much agglomerate and finer grained ash-rocks into which they seem to grade. Dr. Bailey also mentions various sedimentary rocks from

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* Loc. cit., p. 5.

this group; although the sections examined by the present writer have so far failed to show any distinctly non-volcanic clastics. The Coldbrook is exposed over a considerable area northeast and east of the city, making up the greater part of the pre-Cambrian hills in that direction, where its best exposures lie. To the west it is of less importance.

2. *Coastal* (Div. 4). Overlying the Coldbrook is another series of rocks, more altered in its typical exposures than the lower group. Its lower part * is made up of volcanic rocks entirely similar to those of the Coldbrook, from which the writer has not been able to distinguish it. The upper part, however, is composed chiefly of sedimentaries, with some volcanics interbedded. The prevailing schistose structure of most of the rocks of this group in the area examined renders it very difficult to determine their nature without the aid of a thin section in each individual case; hence the proportion of volcanic rock is not very well known. It is often difficult, indeed, even with a thin section, to say whether a rock of this kind is altered felsite, or ash, or volcanic debris recomposed by water and approximating normal sediments.

3. *Kingston* (Div. 5). This is a more altered series than either of the other two, and occupies a strip of land some five miles wide, bounded on either side by a fault line,† and not less than 70 miles in length. Its rocks embrace recognizable surface volcanics, porphyritic lavas and felsitic ash rocks, and also altered types, basic and acid schists, some of which were certainly of volcanic origin, and quite probably all. The relations of the Kingston to the other pre-Cambrian rocks are very uncertain. Dr. Bailey says:

"The same uncertainty rests upon the age of the so-called Kingston group of southern New Brunswick, and which in its western extension becomes in part at least continuous with that to which Prof. Shaler assigns the name of 'the Campobello Series.' By that author . . . . . they are regarded as being Lower Cambrian, but as beds of very similar character occur within a very short distance of the known Cambrian of St. John, and yet bear very little resemblance to it, this supposition seems untenable. As they are certainly older than the Silurian, and in all probability not Cambrian, they must be regarded as pre-Cambrian, the view adopted in the Survey Reports, or as Cambro-Silurian."‡

* As defined by Prof. Bailey in the Report for 1877-8.

† G. F. Matthew, Bull. Nat. Hist. Soc., N. B. XII., 46.

‡ Trans. Roy. Soc. Can. 1889, Sec. 4, p. 8.

The thickness of this series is very great; at New River the section is over eleven thousand feet,* supposed to have been de-deposited in a gradually sinking area, bounded by the faults on each side. The immense erosion which this this series has suffered probably is the key to its more altered character, the rocks now at the surface having been very deeply buried.

4. *Etcheminian.*† This is a series underlying the Cambrian slates in most of their exposures, and unconformable both to them and to the Coldbrook rocks on which it rests. The rocks are wholly sedimentary in their typical exposures, but are believed by G. F. Matthew to have been rapidly deposited by the working over of the softer volcanic beds, and to indicate a time of dying volcanic activity. There is reason to believe that part of the diabase which lies below the Cambrian at St. John is post-Etcheminian (possibly post-Cambrian as well). This series is considered by the last named author to be probably equivalent to the upper part of the Coastal; if so it has considerable directly volcanic material in it.

To sum up, the pre-Cambrian near St. John includes the following groups:

A.—Laurentian.

1. *Portland group*, including Div. 2, with probably parts of Div. 1 in other localities than St. John.
2. *Intrusive granite* and quartz-diorite; perhaps later than the position here assigned to it.

B.—Huronian.

3. *Coldbrook group* or Div. 3, of volcanic rocks.
4. *Coastal group* or Div. 4, of volcanic and sedimentary rocks, in its upper part probably equivalent to the next group.
5. *Etcheminian* or *Basal Series*, of sedimentary rocks, underlying the St. John group.
6. *Kingston group* or Div. 5, of metamorphosed volcanics. Of very uncertain relations; may be post-Cambrian.

Upper Limit of the Pre-Cambrian.

The Cambrian is here considered to be limited by the unconformity at the base of the St. John group. The criterion given by Mr. Walcott for determining the base of the Cambrian, namely the lower limit of the Olenellus fauna, cannot here be applied, as Olenellus has not been found in New Brunswick, though a large pre-Paradoxidean fauna of very primitive type

* G. F. Matthew, Can. Geol. Sur. Rep. 1887-8, p. 4E.

† Trans. Roy. Soc. Can. 1889, Sec. 4, p. 135.

has recently been worked out in Div. 1*b* of the St. John group.* Mr. Walcott † includes the Etcheminian, which contains a few fossils, none satisfactory as determining its relations, in the the Cambrian period. In this case it would become a question as to how much value can be assigned to the unconformity between the Etcheminian and the *volcanic* rocks beneath, and whether the latter might not also be included in the Lower Cambrian. Between the Laurentian and all the later rocks there appears to be a great break, if one may judge from lithologic characters and the lack of conformity in dip in many places.

Satisfactory conglomerates are, as might be expected, lacking at the base of the volcanic series. In some observed cases the rock nearest the contact is a breccia (volcanic); but it is not known whether any of these contacts are not obscured by thrust-planes. That the St. John group is separated from the Laurentian by a great break there is good evidence; a conglomerate at its base has been observed to contain pebbles of the Laurentian rocks.‡

Classification.

It has been thought most convenient in the present paper to discuss the igneous rocks of the Coldbrook, Coastal and Etcheminian together, dividing them according to physical characters, and subsequently to take up the Kingston rocks as metamorphosed phases of these. It is found that the division into *Acid* and *Basic Effusives*, used by Dr. Williams for the igneous rocks of South Mountain, is a very convenient one to employ here, the intermediate types being but poorly represented. The dykes, clearly recognizable as such, are discussed separately, as is also an occurrence of soda granite which has been referred to the Huronian in the Survey Reports. In order to give some clear understanding of the character of the rocks included under these divisions they have been placed in groups which in the sections studied are fairly distinct one from another. It has not been possible to make any well founded generalizations as to the distinctness of these groups in point of time, still less as to their succession. The arrangement is as follows:

Effusive Rocks.

A.—*Acid Effusives.*

1. *Quartz Porphyry.* Compact, quartzose, full of phenocrysts.

* These Transactions. Vol. xiv., April, 1895.

† Correlation Papers-Cambrian, U. S. G. S. Bull., 81.

‡ Trans. Roy. Soc. Can., 1889, Sec. 4, p. 139.

2. *Felsite porphyry.* Few phenocrysts, many characters of surface flows. This includes nearly all the acid effusives, and laps over on the one hand into quartz-porphyry and on the other into an acid porphyrite.

B.—*Basic Effusives.*

1. *Diabase.* This is the chief type.
2. *Feldspar-porphyrites*, including a few basic lavas, strongly porphyritic, purplish in color.

DYKE ROCKS. Only basic dykes are known.

1. *Diorite-porphyrite* and Camptonite.
2. *Diabase* and various porphyrites.
3. *Augite-porphyrite.*

SODA GRANITE.

QUARTZ-PORPHYRY.

Two occurrences in the Quaco Hills, one on the Upper Quaco Road, the other near Golden Grove, seem to merit special notice. The porphyry is even grained, compact and homogeneous, with abundant phenocrysts of quartz and orthoclase, the quartz predominating. No characters of surface flows were observed; the rock appears not to grade into the felsites and ash-rocks in which it occurs, and may be in both cases an intrusive sill or a heavy dyke of post-Coldbrook age. It is very similar in character to the quartz-porphyry ("claystone-porphyry"), which occurs at the base of the Siluro-Devonian in Western St. John County (Dipper Harbor Road).

Under the microscope this rock shows abundant quartz phenocrysts, somewhat corroded at times, but usually with well marked crystal outlines. They show what seems to be a polysynthetic twinning, very fine and faintly marked, visible in sections approximately basal. This may be the rhombohedral twinning mentioned by Prof. Rosenbusch * as occurring in quartz-porphyry. The orthoclase phenocrysts are rather less abundant than quartz; they are usually once twinned, and present no special feature worthy of note. Dark silicates are absent in the sections examined. Iron ores occur in scattered granules. The *groundmass* is microgranitic and of very even texture, composed of quartz and untwinned feldspar.

The color of this rock in its freshest occurrence is a bright pinkish-red; near Golden Grove it is pale green, weathering to brown, and much altered.

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* Mikrosk. Phys. der Massigen Gesteine, p. 355.

FELSITE-PORPHYRY. Pl. XII., XIII., and Fig. A p. 199.

Under this group may be placed the majority of the effusives of the Huronian. Most of the "felsites" and "petrosilex" of the Canadian Survey Reports are either porphyry or porphyry-ash; and some of the rocks described as sandstone, etc., prove on the evidence of thin sections to belong here. The central and most abundant type is a quartz-free porphyry with scattered phenocrysts of orthoclase and plagioclase in a microgranitic or microfelsitic groundmass. Quartz phenocrysts occur in a few sections; in others the amount of twinned feldspar increases relatively to the untwinned till the rock is, strictly speaking, a porphyrite. Flow structure is seen in most of the sections, and trichites, spherulites, perlitic cracks and other characteristically volcanic structures have been observed. Breccias are abundantly found, sometimes very coarse, the fragments being six inches to two feet in diameter. Finer grained rocks, sometimes distinguishable as composed of sharp-edged angular fragments, more often not determinable, are still more common. From the absence of any accompanying rocks of distinctly sedimentary character it is perhaps safest to place these as in most cases fine ashes or tuffs.

This group of rocks bears every indication of being of strictly superficial origin. Their texture is more or less irregular; they are frequently vesicular and flow-brecciated, with few scattered and often broken phenocrysts, being contrasted in these characters with the compact, smooth and uniform appearance and abundance of phenocrysts seen in the last group.

Quartz phenocrysts occur quite rarely, are often broken, but seldom notably resorbed. The quartz in the groundmass is more important. In perhaps a third of the sections examined it seems to be an essential constituent, distinguishable from the feldspars by its brighter polarization colors; it is granular and rarely at all intergrown in granophyric forms. In many cases it is certainly a devitrification product, as is shown by the remnants of original glassy structures still traceable.

Orthoclase phenocrysts are found sparsely scattered in all the sections. They are never very large, mostly 1–4 mm. in length, are rarely resorbed, but not uncommonly broken and the fragments displaced. They are usually twinned after the Carlsbad law, in one case after the Baveno. The orthoclase in the groundmass is mostly granular, but part of the rod-like feldspar in the groundmass of some sections may be monoclinic.

Plagioclase is in some sections more abundant than orthoclase, and rarely entirely fails. Its crystals are less regular in outline than the orthoclase. In the groundmass it sometimes occurs in granular form, being then in some cases, probably in all, of secondary origin (the rock being a consolidated ash). More generally it is seen as little rods lying in a granular mixture of less well individualized feldspathic material.

The *ferromagnesian silicates* are almost entirely wanting. This may be due in part to alteration, but they evidently were never in any considerable quanity. In one instance (Spec. 340 from east of Coldbrook Station), a quartz bearing porphyry with an unusual abundance of phenocrysts, biotite has been observed, now colorless from alteration, but still retaining its optical characters and form.

Magnetite and other iron ores occur commonly, mostly in very small grains. It is frequently titaniferous, as shown by its weathering to leucoxene.

The special interest of this group of rocks lies in the characteristic structures noticeable in them. These afford conclusive proof that the rocks were ejected on the surface and probably in part under water, and that they were originally very like modern volcanic products—acid lavas, scoriaceous, glassy and brecciated towards the surface, more compact and porphyritic below.

Perlitic cracks (Pl. XIII., Fig. 1) appear to be preserved in several specimens, but in one only were they clearly and certainly determined. This is part of a "felsite" outcrop on the Hammond River below Upham; this felsite is strongly flow-lined, somewhat brecciated and spherulitic in parts. The perlitic cracks are preserved in some brilliantly polarizing mineral (calcite ?), and are most easily seen with crossed nicols, though they are visible in ordinary light.

In the same flow are the best preserved examples of large spherulites that I have seen from New Brunswick (Pl. XII., Fig. 1). These are rather irregular in form, seldom complete, but retain a radial structure. They shot out from various solid bodies in the magma, feldspar phenocrysts, grains of magnetite, etc., paying no regard in their growth to the flow-lines already existing. The rods of quartz and feldspar seem now to be broken down into elongated granules with straight lateral edges (Fig. A); but there is no evidence in the specimen that this was not the original structure of the spherulites. The groundmass in which they occur is microgranitic, and, along with the spherulites themselves, is filled with minute trichites, seen in Fig. A, composed of one or more curving black needles shooting out from a grain of magnetite. These needles are now partly broken up into a succession of granules, like a string of beads; in other parts they are unchanged. They are evidently earlier than the spherulites, for they show a general direction following that of the flow lines, without regard to the spherulitic structure.

Microspherulites, showing the revolving cross under crossed nicols have been observed in a red felsite from Hanford Brook, collected by G. F. Matthew. Nodular felsites, in which the radial structure is not seen, occur in several places. This structure in English rocks is believed by some authorities to be generally secondary, arising from a progressive alteration of the rock proceeding from a central vesicle or some point of weakness. From the traces of radial structure preserved, it seems probable that, in some instances at least, the nodules in New Brunswick felsites are altered spherulites of large size. At Shanklin, near

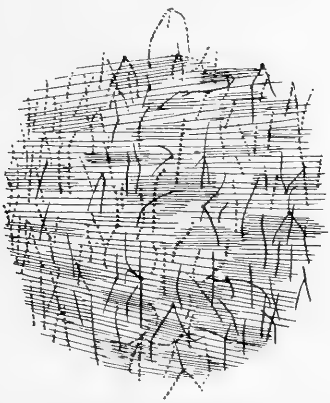

FIG. A. *Trichites in spherulitic felsite. Spec. 664. Magnified 133 diameters.*

Quaco, is a bright red nodular felsite forming an outlier in Subcarboniferous shale. It is lithologically like the volcanic hills near by, and probably of the same age. The nodules in this rock are strongly marked in the weathered specimens, from the abundance of hematite in their outer zones; they often fall out of the matrix on slight weathering, being apparently more silicified and better able to resist alteration. They have usually a central filling of feldspathic material free from iron; the iron has collected chiefly at their surfaces. In thin sections traces of a radial structure seems to be preserved in the arrangement of the secondary hematite flakes. The whole substance of the rock is much silicified, but both in the transparent centres and in the deeply stained outside a minute pilitic structure is retained, apparently of feldspar rods arranged approximately parallel to the flow lines. If the apparent remains of radial structure are not illusory, this would seem to indicate either:

1. That a radial spherulitic structure could form in a rock already in large part crystallized, or

2. That this pilitic structure of the groundmass may be of secondary origin.

Of these two, the former supposition seems to the writer the more probable one.

The Survey Reports mention in general terms,* and in one case more particularly, gradations of these felsites into the holocrystalline rocks with which they are in places associated. Dr. Ells speaks of these holocrystallines as basal portions of volcanic flows; Dr. Bailey† considers that north of the Germaine Brook as an extreme case of metamorphism. The present writer has not yet been able to obtain a complete series showing this gradation, though a partial one was made at Germaine Brook. But in none of the felsites sectioned is there evidence of gradation into crystalline rocks, either by slower cooling or subsequent metamorphism. That such deeper-seated facies of the Huronian igneous rocks exist there can be no doubt, and it would probably be revealed by more extended study.

The acid *breccias* and *ash-rocks* are very abundant. Coarse felsite breccias occur east of Coldbrook, where they contain larger rounded or pear-shaped masses, probably volcanic bombs; on the road skirting the south flank of Bloomsbury Mountain, here composed of a pale greenish-gray silicified felsite, strongly flow-lined and perhaps a devitrified glass; at Titus' Mill on the Hammond River, here being partly a devitrified glass breccia; in a railway cutting near Henry Lake, and elsewhere. The finer breccias or coarse ash-rocks are sometimes schistose, as for instance, a greenish-gray breccia not far east of Coldbrook. With increasing fineness they are more and more altered and less easy to recognize, the fine-grained, flinty felsites and petrosilex showing no characteristic structures which can be considered original.

These fine-grained rocks often show aggregations of chloritic material in rounded or irregular spots with fairly well defined outline. Aside from this they are uniformly micro-crystalline in structure, made up of feldspar with a quarter or less admixture of quartz, and scattered magnetite grains. Occasional large grains and porphyritic crystals of feldspar are seen in some specimens.

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* Ells, 1877–8.

† Bailey, 1877–8. Discussed in this paper under soda granite.

Diabase.

Except the felsites this is the most abundant rock of the Coldbrook group, and forms also a considerable part of the rocks referred to the Coastal series in 1887–8. It occurs as surface flows as well as intruded sills and dykes. At Racehorse Point, east of St. John City, it crops out on the shore as a heavy dyke in the coarse green and red sandy slates that are overturned on the fine grey slates of the St. John group.* This dyke has baked the adjoining slate into a hornstone very like the edges of the igneous rock itself, and the contact of the two is not easy to distinguish. Dr. Gesner in 1840† mentions it as a dyke, but supposes that it has fused the slate near by, and thus effaced the line of contact. The Survey Reports‡ do not recognize it as a dyke, but consider it, apparently, as an altered sediment or ash-rock. In thin section, however, it is unmistakably a diabase, and on careful examination the line of contact with the slates was traced on each side. Under the microscope this contact is perfectly sharp and clear, the igneous rock being dense, almost opaque, with scattered plagioclase phenocrysts. The slate does not show much change; the parallel arrangement of the granules is not noticable, and minute grains of a brightly polarizing mineral are developed near the edge. The diabase of the central parts of the dyke is tolerably fresh; the augite occasionally shows crystal outlines, but mostly moulds the feldspar. No olivine was observed, but a peculiar oil-green substance, indistinctly fibrous or matted, with a high refractive index and bright aggregate polarization, appears occasionally, and is probably an alteration product of olivine, perhaps allied to Becke's *pilite.*

At some little distance back from the shore, near the penitentiary, the diabase crops out again, here being in part a surface flow, finer grained and strongly vesicular, and separated by a sharp line of contact from the coarser, non-vesicular diabase lying northwest of it. The latter contains included masses of white-weathering flinty felsite, which seem to belong just north of it, and are very like the supposed ash-rocks underlying the Etcheminian north of the city.

From the foregoing it is clear that a part of the diabase, the dyke on the shore and the heavier dyke or sill back of it, must be later than the slate and felsite through which they cut. Of the relative age of the vesicular diabase there is no good evidence; though it appears to be older than the sill. The slate is

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* Trans. Roy. Soc. Can. 1890, Sec. 4, p. 127.

† Geol. Sur. Prov. New Bruns., Rep. 1840, p. 11.

‡ Geol. Sur. Canada, Rep. 1871, p. 137.

considered Etcheminian by G. F. Matthew*; hence this diabase is post-Etcheminian, possibly Cambrian or later.

Provisionally it may be placed as pre-Cambrian.

The diabase is again well exposed on the west side of the harbor of St. John, in a series of hills on the southeast border of the Cambrian valley. It is made up, as far as can be seen, of a number of surface flows, which are accompanied by a little slate, apparently interbedded, and were perhaps partly sbumarine. The characters of surface flows can be seen in some others of the many outcrops that occur in all parts of the Huronian hills,

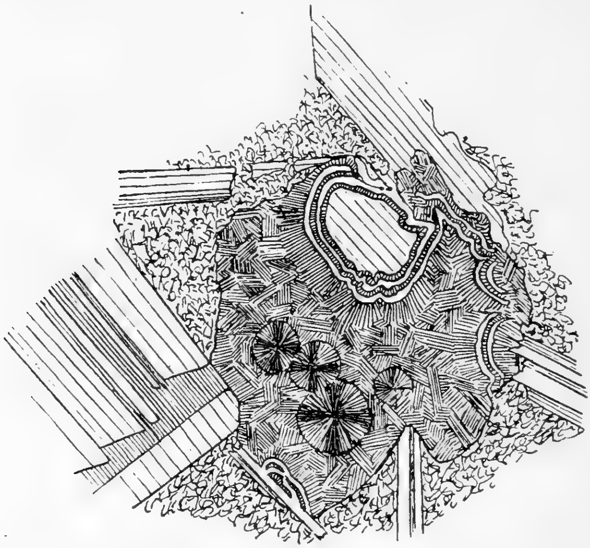

FIG. *B*. *Vesicle in diabase, showing agate-like banding of feldspar (?) and chlorite. Magnified 70 diameters. Spec. 150.*

others are more probably intrusive sills. All are normal diabase, without olivine, and with an almost colorless augite. The vesicles are mostly lined with quartz, and filled with chlorite, sometimes with hornblende. The chlorite is very often spherulitic and shows the beautiful Berlin-blue polarization color. Secondary growths of a mineral which seems to be plagioclase are known; it is not twinned, but appears to be sometimes optically continuous with the feldspar rods around the vesicle. It

* Trans. Roy. Soc. Canada, 1790, Sec. 4, p. 127.

is at times intergrown in alternate concentric layers with the chlorite of the vesicles, as is shown in Fig. *B*.

Basic *ash rocks* occur abundantly and can sometimes be seen to be made up of diabase fragments. But most of them are too far altered to be certainly identified.

Porphyrites.

Under the group may be placed a considerable number of outcrops of strongly porphyritic basic effusives, mostly of purplish black color and not certainly known to grade into the diabases. They form heavy beds, apparently thick surface flows, very vesicular for the most part and containing phenocrysts of plagioclase which in one case, a porphyrite from south of Golden Grove, are remarkably fresh and glassy.

Under the microscope they show a somewhat ophitic fine-grained groundmass composed of feldspar rods, minute grains of augite and magnetite in which are scattered the feldspar phenocrysts, those in the rock from Golden Grove being of the *microtine* habit, water clear, repeatedly twinned and somewhat corroded. No augite phenocrysts were seen. In a porphyrite from near Henry Lake the vesicles are filled with a zeolite, determined as thompsonite on its micro-characters.

Metamorphism.

The alteration as seen in these Coldbrook and Coastal rocks is very varied in amount. *Devitrification* is universal; in no instance has any trace of remaining glass been identified. The resultant microcrystalline mass varies in texture from a microfelsite, in which the minerals are scarcely distinguishable to a moderately fine microgranite, in which are local accumulations of coarser grains. Shearing occurs sometimes in the porphyries, quite generally in the ash-rocks. In the Coastal especially, it is usually so much developed as to produce a schist. The last named alteration is accompanied by the production of great amounts of epidote; this mineral occurs less abundantly in the massive flows. Uralitic hornblende is a frequent alteration product of the diabase, retaining usually the form of the augite which it replaces. In no observed case is the change carried so far, either in the acid or basic rocks, as to produce a strongly schistose or subgneissic structure. It is not intended to assert that such rocks may not occur locally, but only that they are evidently not usual.

SODA-GRANITE. Pl. XVI. and XVII.

A high ridge stretching from Hardingville on the Germaine Brook to the great bend in the Hammond River below Upham consists of a red granitic rock called syenite (hornbende-granite) by the Survey officers, but which on microscopic study appears to be an augite-soda-granite. The Germaine Brook and Hammond River run at the foot of its steep eastern slope; on the other side lies a broken country, little opened up. The rock was considered by Prof. Bailey as an extremely metamorphosed phase of the breccias and felsites which surround it; and he cites instances of the transition of the one into the other, which the writer has not yet been able to completely follow. *

In regard to Prof. Bailey's conclusion, it must be observed that microscope sections have failed to show any extreme metamorphism in the Coldbrook or Coastal groups. They have frequently a secondary cleavage developed, which often amounts to an imperfect schistosity. But of the entire re-formation of the minerals in the rock so as to make a gneiss, still less a granite, I have seen no instance in the post-Laurentian rocks of this region. If the rock is not a subsequent intrusion, the view of Dr. Ells, stated with regard to a number of such areas of crystalline rocks occurring near the borders of the volcanic areas, seems more acceptable. † He regards them as being basal parts of volcanic flows, their crystalline character being due to slow cooling.

Prof. Bailey describes the passage from felsite into "syenite," as follows:

"With the dark grey petrosilex are irregular beds of pale red and red felsite, which in approaching Titus' Mill become at the same time more frequent and more crystalline. In some portions . . . a distinct but usually highly contorted stratification is discernible, but other portions are quite homogeneous, and by admixture of a dark green mineral resembling hornblende become imperfect syenites. . . . It is supposed that these syenitic hills . . . are simply the petrosilex and breccia in a more altered form. That they are in great part of fragmentary origin is very evident, and even where apparently most crystalline a rounding of the grains of quartz, and the occurrence of irregular cavities or vesicles suggests that all have been produced by like agencies." ‡

The microscopic appearance of the "syenite" throws consid-

* Geol. Sur. Can. Rep., 1877-78, p. 8, DD.

† Geol. Sur. Can. Rep., 1877-78, p. 3, D.

‡ Loc. cit.

erable new light on its origin. In thin section (Pl. XVI., fig. 1) it appears as a rather coarse but very even-grained soda-granite, apparently of igneous origin, the quartz often granophyric (whence the rounding of its grains of which Dr. Bailey speaks); the dark silicates are augite and brown and green hornblende, the two latter apparently secondary after augite. The feldspar is partly idiomorphic, partly granophyric or granitic. Towards the edges of the mass the rock becomes fine-grained, and shows in thin section (Pl. XVI., fig. 2) a mass of interlacing rods of feldspar with comparatively little quartz, and augite in small irregular granules. The characters cited are sufficient to show that this rock has cooled from fusion. Did it occur in the midst of highly metamorphic rocks, gneisses and crystalline schists, it might well be supposed that its fusion was but an extreme phase of metamorphism. But in view of the slightly altered character of the rocks surrounding it, it seems almost certain that the fusion was followed by a notable displacement, and the rock is therefore a stranger in its present association and must be classed as igneous. The peripheral phases, as far as noted, accord with this view; we find there a rock approaching a porphyry in structure, instead of a gneiss. How nearly the granite is connected with the felsites around it, it is not now possible to say.

Microscopic characters. The rock is an *augite-soda-granite*, containing at most, perhaps, one-third free quartz, and a varying amount, sometimes quite small, of ferromagnesian silicates. In its central parts it is strongly granophyric (Pl. XVII.); towards the edges it loses that feature and finally becomes fine-grained with a rod-like form to the feldspars, and almost no quartz.

The *quartz* calls for no especial comment. It is, as noted, largely intergrown with the feldspar; when not so, it appears to have been the last constituent of the rock to form, never showing crystal outlines.

The *feldspar* is partly a twinned feldspar, apparently anorthoclase, and partly untwinned. Much of it is so altered by kaolinization that its nature cannot be determined; the more altered parts are made almost opaque by the presence of minute red flakes (hematite ?). The untwinned feldspar rarely shows crystal outlines and is often intergrown with quartz. The twinned feldspar shows an exceedingly fine and regular twinning with a small extinction angle, and occurs mostly in idiomorphic crystals imbedded in the quartz-orthoclase mass. From the regularity and fineness of its twinning this feldspar is considered to be more probably anorthoclase than a fine grained plagioclase.

Besides the anorthoclase, a few crystals of the ordinary plagioclase type were observed.

Augite occurs in poorly developed crystals or irregular grains, almost colorless and with no apparent pleochroism. It is mostly altered to hornblende, chlorite or epidote. In the strongly granophyric specimens the augite and other ferromagnesian silicates are in very small amount.

Brown hornblende. A pale brown hornblende, with a very high extinction angle, 25° maximum, occurs in moderate amount. It is in part at least secondary after augite, but some of it seems to show its own crystal outlines, and if so, may be considered original. Its pleochroism is:

$\mathfrak{a}$—faint brownish yellow,
$\mathfrak{b}$—pale reddish brown,
$\mathfrak{c}$—pale yellowish brown,

$$\mathfrak{a} > \mathfrak{b} > \mathfrak{c}.$$

Green hornblende. This is in varying quantity, and appears to be in all cases paramorphic after augite and brown hornblende. It has the usual colors and pleochroism of uralitic hornblende, though its structure is almost compact. The stages in the alteration of the augite appear to be,

1. Brown hornblende,
2. Green hornblende, sometimes bleached before passing into
3. Chlorite.

Epidote occurs as an alteration product, but apparently not of this series; the conditions of its formation must have been different. In some sections no augite or brown hornblende is found, but only an aggregate of green hornblende, epidote and chlorite.

Apatite is an abundant accessory, in the usual long prisms, which are rather more abundant in the quartz.

Magnetite occurs in small irregular masses and is in part titaniferous. *Pyrite* is occasionally to be noticed.

Zircon appears in every section examined in crystals of square cross section. In the concentrates these are seen to be made up of the unit prism and pyramid, rarely showing their edges in the slightest degree modified. This character of the crystals is much in contrast with the rather abundant zircons of the intrusive granite-diorites of the Laurentian. The latter have the unit and second-order prism and unit pyramid much modified by development of several other faces, giving them a rounded outline, while the zircons of the soda-granite are sharp-edged and clean cut. The difference in character may perhaps be due to the conditions of solidifying, more probably to the chemical composition of the magma.

In the concentrates a few grains are found of a mineral with ultramarine-blue color, and pleochroism ultramarine to colorless. This is thought to be probably a soda-hornblende, allied to glaucophane. Its refraction and polarization indices are about those of hornblende and it is (?) biaxial; but its properties could not be further determined.

The peripheral phases of the soda-granite are not thoroughly known. The complete gradation from it into the felsite-breccia described by Dr. Bailey as occurring at Titus' Mill, the writer has not succeeded in finding. At other points the granite was seen to be fine-grained and to have lost its characteristic bright red color. It was not at all gneissic, however, nor was it strongly porphyritic, and of further transition between it and the felsites no trace was seen.

Under the microscope (PL. XVI., fig. 2) this fine-grained facies shows a more or less panidiomorphic structure of feldspar crystals which exhibit a decided tendency towards the rod-like form. One or two large crystals appear to be porphyritic in the rest of the mass. The feldspar is largely plagioclase, the rest orthoclase, no anorthoclase being certainly recognizable in the sections. Augite? appears in minute grains scattered all through the mass; they are too small to show well the characteristic optical properties, and have little or no crystal outline.

An analysis was made of the soda-granite from above Titus' Mill, spec. 661. This was a fairly average specimen, moderately granophyric, with an unusually large amount of dark silicates present. The following results were obtained (column I.):

ANALYSES OF SODA-GRANITES.

I. Titus' Mill, Upham, N. B.
II. Kekequabic Lake, Minn. U. S. Grant.
III. Pigeon Point, Minn. W. S. Bayley.

	I.		II.	III.
	a	*b*		
SiO_2	64.86	64.79	66.84	72.42
TiO_2	0.70	0.63	.....	0.40
Al_2O_3	15.02		18.22	13.04
Fe_2O_3	5.53	5.60	2.27	0.68
FeO	1.01	0.86	0.20	2.47
MnO	0.18	0.40	.....	0.09
CaO	2.61	2.63	3.31	0.66
MgO	1.42	1.51	0.81	0.58
Na_2O	3.92	3.93	5.14	3.44
K_2O	2.37	2.35	2.80	4.97
CO_2	0.55		.....	.....
P_2O_5	.....		tr	0.20
Loss on ign.	1.73	1.78	0.46	1.21
	99.89		100.05	100.37

With this analysis are placed for comparison analyses of anorthoclase granites from Kekequabic Lake* (II.) and Pigeon Point† in Minnesota (III.). The Upham rock agrees fairly well in composition with that from Kekequabic Lake, being somewhat lower in alkalies and alumina and higher in iron percentage. Dr. Grant describes the latter rock as dull pink in color, feldspathic, with abundant augite and comparatively little quartz, and shows that it is an intrusive rock, exhibiting porphyritic facies. It would seem to be less altered than our rock, and consequently has a much larger proportion of augite; otherwise the resemblance is quite close.

The results of separation with potassio-mercuric iodide solution were as follows:

Sp. g. 2.54—2.57	2. %
2.57—2.62	26.
2.62 - 2.67	41.
2.67—2.70	7.
2.70—2.73	6.
2.73—3.16	10.
> 3.16	8.
	100

The part falling between 2.62 and 2.67 was chiefly quartz and impure feldspar. The feldspar between 2.57 and 2.62 was analyzed with the following results:

SiO_2, 66.62;	Al_2O_3, + Fe_2O_3, 21.22;	CaO, 0.82;
MgO, not det.;	Na_2O, 6.73;	K_2O, 2.10.

In its outward appearance and in many details of its structure this soda-granite is very like the "red rock" of Pigeon Point, in Minnesota, so fully described by W. S. Bayley.‡ Dr. Bayley determined the red rock as an anorthoclase granite with porphyritic phases.

Dr. Bayley shows that the red rock is to be considered as a contact product resulting from the complete fusion of red sandstones by an intruded gabbro. If the view held by Prof. L. W. Bailey as to the origin of the soda-granite be correct, there is a further likeness to the Pigeon Point rock, as the metamorphism which could produce a rock of such type must be supposed pushed to the point of fusion. For reasons already stated, however, the writer is unable to take this view, and would consider it rather as an igneous rock of unknown relations to the felsites.

* Minn. Geol. Survey, Ann. Rep. 1892, p. 41.

† Amer. Jour. Science (3) XXXVII., 54. See also U. S. G. S. Bull. 109.

‡ Bull. 109, U. S. G. S.

The Kingston Group.

This group presents a series of volcanic rocks parallel to those of the Coldbrook, but far more altered. The acid members are strongly sheared, often unrecognizable as volcanic, and with a great development of secondary micas, making a quartzose or feldspathic mica-schist. Some of these schists retain their porphyritic crystals with clear cut edges and comparatively little altered, though the ground mass is all recrystallized. Ash rocks, now changed to flinty felsites, are sometimes still recognizable, but no doubt most of them are too much metamorphosed to be determined.

The basic rocks of the series are even more changed. Though mostly less cleaved, they are coarsely crystalline hornblende schists, with no traces of their original structure visible under the microscope. Remnants of the porphyritic feldspars sometimes still appear as white spots scattered through the dark schist, but their original form is lost.

These remarks apply to the New River exposures, the only ones examined by the writer. A modification of them might be necessary on study of other areas of Kingston rocks which show certainly a greater variation in the amount of metamorphism than is seen at New River.

Comparisons.

In their original character and degree of preservation the New Brunswick effusives may best be compared with those of South Mountain. The volcanics of the Boston Basin, as far as the writer has seen them, seem to be more dense and massive, less shattered and epidotized and more crystalline than ours. In field characters there is a considerable resemblance to the volcanic series along the Maine coast, at Eastport and Mount Desert; but I have seen no petrographic descriptions of these.

The rocks of the Coldbrook group seem to be much less sheared than almost all of the South Mountain rocks, to which our Coastal volcanics show a closer resemblance in this respect. The Coldbrook felsites are also of finer grain, their recrystallization not having proceeded quite as far. The characteristic structures of volcanic rocks, as has already been detailed, they possess in great perfection, the only structure of which I have not seen satisfactory examples being chain spherulites.

It is worthy of note that all these "ancient volcanic rocks," as Dr. Williams happily termed them, lie unconformably underneath Palæozoic strata. Whether they are considered as the lowest member of the Palæozoic series or the uppermost one of the pre-Cambrian rocks would seem to depend chiefly on what may be taken as the base of the Palæozoic. In New Brunswick it is rather more than elsewhere convenient to consider them as at all events pre-Cambrian, and to take the very persistent coarse grey sandstone at the base of the St. John group as the dividing line. This would leave both the volcanic series and the Etcheminian among the pre-Cambrian rocks. Nevertheless their age is probably not greatly different from the so-called Cambrian effusives lying southwest of them.

THE DYKES.

In all the rocks referred to the "Laurentian," we find a great abundance of dykes. In the later rocks they are few in number. In the volcanic series they are, naturally, not easy to recognize; a number of supposed sills are known, but of small dykes crossing the bedding of the rocks very few. The Etcheminian contains one certain dyke, and probably others. In the St. John Group one dyke is reported from near the city, but I have not seen specimens of it. Though none have been met in the Devonian slates, a few occur in the Sub-carboniferous.*

The vast majority of the dykes in Laurentian rocks, as well as the dyke and sill in the Etcheminian, are ordinary *diabase*, more or less altered and often porphyritic. With these occur several dykes which can be grouped under Prof. Rosenbusch's term of *Diorite-porphyrite*, though they border on camptonite. The Sub-Carboniferous dykes, with one or two occurring in older rocks, are *augite-porphyrite.* Some dyke rocks appearing to be of other types are known, but are all so altered as to be unrecognizable.

As a rule no general trend is to be distinguished in the direction of the diabase dykes. An exception is seen at Pleasant Point, where the granite is seamed with dykes, most of which are perfectly straight and parallel, with a north-west and, south-east direction, parallel to the great cross-fault of the Short Reach.

DIORITE-PORPHYRITE. Pl. XIV. Figs. 1 and 2.

Under this name may be grouped a number of dykes varying a good deal in character, but all distinguished by a groundmass consisting of sharply idiomorphic hornblendes, lath-shaped feld-

* These notes apply merely to the neighborhood of St. John.

spars and some interstitial quartz, with phenocrysts chiefly feldspar, sometimes hornblende, occasionally quartz. They are holocrystalline, rather fine grained, and distinguishable macroscopically from diabases by their paler gray color, granular texture, and often by the short hornblende rods which stand out on weathered surfaces. The texture is mostly uniform, but in two cases is extremely irregular in different parts of the same dyke. They are singularly like the basic segregations in the granite, which latter they cut in several places, and are perhaps to be connected with it as the last member of the intruded series, injected after the rest had solidified.

Under the microscope they show numerous well formed crystals of *hornblende*, varying in size according to the width of the dyke, with prismatic faces always well developed, often also with good terminal faces. The prismatic faces are *m*, usually *b*, rarely *a*. The terminal faces are not safely determinable, but apparently *r* is present, and also a steep pyramid or clino-dome. In the less altered specimens (293, 294, 603, 608) the hornblende is brown, showing a strong pleochroism :

𝔞—brownish-yellow.

𝔟—brown.

𝔠—greenish-brown.

The extinction angle is high, not less than 17°, and the colors are scarcely so deep or so red tinted as those of basaltic hornblende. It appears therefore to be a brown variety of the common kind.

Green hornblende sometimes appears as a secondary rim at the edges of the brown crystals, more commonly as a paramorph after them ; all stages of the change can be seen in different crystals, the alteration beginning at the edges or in cracks. In either case the orientation of the two varieties is the same, and their extinction identical.

In the more altered dykes (90,225,284 and 336), the hornblende is entirely green, its pleochroism being

𝔞—pale brownish yellow,

𝔟—green,

𝔠—bluish green.

The outlines tend to become less distinct with increasing metamorphism.

In spec. 284, from a small dyke, there are, instead of the usual corroded feldspar phenocrysts, abundant long rods of green hornblende, from 0.2 to 0.5 mm. diameter, and several millimeters in length. They are not noticeably corroded. Strictly speaking, this rock is a *camptonite*, but its real affinities seem to be with the diorite-porphyrites. Spec. 608 also shows porphyritic hornblendes, brown like those of the groundmass, along with the feldspar phenocrysts.

Feldspar phenocrysts are present in all but one of the sections. They are much corroded and kaolinized and surrounded by a rim of clear feldspar, probably secondary, at least later than the greater part of the groundmass. When not too much altered, they can be seen to be a very basic plagioclase with extinctions up to at least 40°, indicating approximately bytownite. Twinning after the Carlsbad and Albite laws is observed, the latter polysynthetic. The crystals are strongly zonal towards the edges, the clear outer rim becoming rapidly more acid till it is an oligoclase with nearly straight extinction. The zonal outside and decayed core are not always coterminous, the latter being often more or less zonal. There is no evidence that the clear outer rim formed later than the consolidation of the rock; the decay of the feldspar within may well be due to its different composition. But it certainly formed after the greater part of the groundmass had crystallized out.

The feldspar of the groundmass is composed in part of lath-shaped crystals, with the extinction angle of labradorite, zonal at the edges like the phenocrysts, but not corroded, though often decayed at the centre. The rest of the feldspar occurs as zonal rims to the labradorite rods and as irregular grains packed in among them. It is always fresh, and judging from its extinction angles its composition varies from an acid labradorite to oligoclase or even albite.

Quartz occurs as a phenocryst in spec. 336 and shows well defined crystal outlines, somewhat corroded, not much broken up. It occurs in the groundmass of all the dykes, though never in very large amount, and is then of the same age as the clear feldspar forming the zonal rims and irregnlar grains, that is, the last constituent to crystalize.

Magnetite and *pyrite* occur in small, well formed crystals. *Apatite* is rare. The hornblende of the concentrates appears to show transition to an ultramarine blue variety, probably a soda-hornblende.

Flow structure is very well seen in some of these dykes, as shown in Pl. XIV., fig. 2.

An analysis of the diorite porphyrite, spec. 603, gave the following results :

$Si\,O_2$	48.98
$Ti\,O_2$	0.56
$Al_2\,O_3$	17.76
$Fe_2\,O_3$	2.14
$Fe\,O$	6.52
$Ca\,O$	8.36
$Mg\,O$	2.09
$Na_2\,O$	6.77
$K_2\,O$	2.08
Fixed CO_2	0.82
Loss on ignition	4.50
	100.58

I am not aware that this rock has been reported before from North America.

Diabase.

It seems very likely that this group of dykes is connected with the great surface flows underlying the Cambrian slates, and of "Huronian" age. There is a great variety in their character, the majority being normal diabase, but many having the feldspar in two or three generations, and some showing porphyritic augites.

The normal diabase has a colorless or almost colorless augite, well twinned feldspar rods and magnetite in small, irregular grains. It is usually considerably altered, the augite being either uralitized or chloritized. In about half the dykes green hornblende, uralitic or compact, has entirely replaced the augite, still retaining the outward form of the original mineral.

Some of the diabases are quite porphyritic, the plagioclase phenocrysts being short and stout, the groundmass containing small twinned rods and sometimes apparently a third generation. These appear to be more feldspathic than the rest.

Contact action has not been noticed except on the limestones. These are bleached by even small dykes for about 3 or 4 mm. from the edge; and in the case of a fifteen foot dyke near King's Mill, Fairville (spec. 63), there is a development within a few millimetres of the edge, of epidote, titanite and pale green hornblende of tremolitic habit—𝔟 and 𝔠 very pale green, 𝔞 colorless. These constituents entirely replace the lime just along the contact. The diabase itself has the usual contact character.

A single dyke (?) in the lower Coastal rocks west of the Coldbrook Marsh shows a departure from the ordinary type enough to merit special notice. It is rather coarse-grained, the magnetite in unusually large grains with a tendency towards skeletal forms. The augite is quite strongly colored, and there is a not unimportant amount of *free quartz* (See Pl. XV., Fig. 2). The microscopic description is as follows :

Augite nearly or quite as abundandant as the plagioclase, violet-brown, slightly but distinctly pleochroic, mostly moulding the feldspar, occasionally idiomorphic.

Plagioclase in large, rather short lath-shaped crystals, idiomorphic with respect to the augite, water-clear, coarsely twinned. Extinctions are about those of labradorite.

Magnetite is in unusually large grains, mostly of the peculiar skeletal forms which are sometimes referred to titaniferous iron ;* idiomorphic with respect to the feldspar and most, if not all of the augite, but with edges and angles frequently rounded.

Apatite in long slender needles varying from .05 mm. in diameter down to indeterminable minuteness; included in all other constituents, though rarely in the magnetite.

Quartz in allotriomorphic grains, moulding the feldspar and augite, forms a not unimportant constituent of the rock. It would seem to be original, judging from the unusual freshness of the rock, the size and uniformity of the quartz-grains, and the presence of apatite needles in them as abundantly as in the feldspar.

An analysis of this diabase gave the following results :

SiO_2	46.61
TiO_2	0.55
Al_2O_3	15.34
Fe_2O_3	8.40
FeO	8.14
MnO	0.39
CaO	9.27
MgO	5.27
Na_2O	3.04
K_2O	1.41
Loss on ignition	1.41
	99.83

The presence of free quartz in so basic a rock is unusual The large size of the magnetite crystals, however, probably indicates that the early stages of cooling were slow, giving time for the basic constituents to crystallize out more completely than usual, leaving at the end a more acid residue, which was able to slightly corrode the first formed crystals of magnetite, and produced some free quartz on crystallization. The same phenomenon is seen in the diorite-porphyrite.

* The analysis, however, fails to show any considerable amount of titanic acid.

Augite-porphyrite.

The dykes in Sub-carboniferous sandstone at Poverty Hall Point appear to be of this rock. The phenocrysts are chiefly augite, the larger ones being entirely, the smaller ones frequently chloritized. They present the usual short stout crystals characteristic of augite, and are quite abundant. Augite occurs also in the groundmass, but is mostly destroyed. *Magnetite* is abundant in small crystals. *Olivine* phenocrysts occur rarely. The *plagioclase* is confined to the groundmass and is in small lath shaped crystals. A micaceous mineral occurring in small plates in the groundmass is perhaps an altered biotite, and is quite abundant.

With these Carboniferous dykes may be placed from lithological resemblance spec. 148, a dyke in the volcanic series at Lily Lake, known as labradorite-porphyrite. It contains large phenocrysts of completely altered feldspar. Spec. 251 is perhaps also related, showing augite and occasional feldspar phenocrysts and a much altered groundmass which contains a great abundance of plates of altered biotite (?) in a feldspathic base now apparently recrystallized and granular.

Additional Notes on the Laurentian Rocks.

Some further notes may be made as to the Laurentian areas in a few places otside of the district studied last year; though no general examination was made of them.

A more massive gneiss than has yet been noticed occurs beyond Sutton Station, on the Canadian Pacific Railway; it is strongly feldspathic, banded, and contains a bed of limestone.

The intrusive granites occur both east and west of the mapped district. To the southwest are also large masses of granite of a different type, non-porphyritic, much altered, and perhaps older than the Indiantown granite. At Musquash the contact is exposed between it and the Devono-Silurian limestone. The granite is here clearly seen to be the older rock.

The gabbro (olivine-norite) hill north of Dolin's Lake presents less variation in feldspar contents than the small Indiantown exposure. Its grain varies greatly, crystals being sometimes 2″ across, sometimes finely granular and almost ophitic (Pl. XV., Fig. 1), as in spec. 474 This section fails to show olivine; it is made up of colorless augite, weakly pleochroic hypersthene, biotite, and basic plagioclase, the latter giving a maximum extinction of about 36°, and occurring in more or less lath-shaped crystals, which however do not distinctly appear to be older than the bisilicates, and are certainly in part younger. The biotite is later than much of the feldspar. Magnetite and apatite occur scatteringly. This phase of the norite appears to occur as a heavy dyke or intrusive knob in the main mass.

The relations of the norite to the surrounding rocks could not be determined. It is cut by three sets of dykes.

1. Eurite and granite-veins, probably connected with the granite.
2. Diabase.
3. Augite-porphyrite, older than the diabase, and very much decayed.

Other Volcanic Rocks in New Brunswick.

The foregoing article deals with but a small part of the volcanic rocks of New Brunswick. Besides the extension of the Coldbrook and Kingston groups to the northeast and southwest, and other detached areas lying further inland, there is a great body of pre-Cambrian rocks, chiefly volcanic, in the northern part of the Province, forming a considerable part of the broken and unsettled country about the headwaters of the Tobique, Nepisiquit and Northwest Miramichi rivers. In several of the later formations, also, great quantities of volcanic material occur, notably in the Silurian of Passamaquoddy Bay, at the base of the Devonian around the shores of Baie Chaleur, in the Sub-carboniferous at the Blue Mountains near the Tobique River, around the head of Grand Lake and elsewhere, and in the Triassic at Quaco and Grand Manan Island. No petrographic study of any of these rocks has yet been made, and they afford a fruitful field for future investigation. The great areas of Devonian granites extending across the centre of the Province from the southwest nearly to the northeast boundary would also well repay study, especially with regard to their well marked contact phenomena.

Summary.

The Huronian in Southern New Brunswick is in large part made up of surface volcanic rocks. The lower part or Coldbrook group is almost exclusively volcanic; the upper part or Etcheminian is clastic, while the intermediate Coastal contains both volcanic and sedimentary members. The effusive rocks include lavas, breccias and tuffs, and with them may be placed a holocrystalline soda-granite which is probably either an intrusion or a very thick surface flow.

The rock types represented may be conveniently divided into acid and basic, the intermediate varieties being little developed. The acid rocks are more abundant. They are chiefly felsite-porphyry and show all the characteristic structures of surface flows. Vesicles, flow-lines and flow-breccia are very common, and the scattered phenocrysts are often broken and displaced. Spherulitic and perlitic structures, trichites and skeleton crystals are sometimes excellently preserved. The basic rocks are chiefly diabase, and are in part as late as the Etcheminian. Breccias and tuffs are very abundant. The alteration is not excessive except in the tuffs, many of which are now unrecognizable. The massive rocks are completely devitrified but otherwise not much changed; schistose cleavage is marked in the more highly metamorphic areas, but is generally absent.

The soda-granite is a quartz-anorthoclase rock with augite and hornblende as the dark silicates. It shows a very strong granophyric structure in the central part, but is finer grained and somewhat porphyritic towards the edges.

The dyke rocks are all basic and predominantly diabase; a number belong to the rare type of diorite-porphyrite. The latter is a panidiomorphic rock with feldspar, brown hornblende and subordinate quartz. The age of the dykes is probably pre-Cambrian,* excepting a few of different type from the rest.

In concluding, I wish to express my acknowledgments to Prof. J. F. Kemp, for his assistance and advice in carrying out this study. I am also much indebted to my father, Mr. G. F. Matthew, especially as regards the details of local geology.

Geological Department,
Columbia College, April, 1895.

DESCRIPTION OF PLATES.

PLATE XII.

Fig. 1. *Spherulitic structure* in red felsite-porphyry (apobsidian) from the Hammond River below Upham, N. B. This section shows under higher magnification well preserved trichites throughout both the spherulitic and non-spherulitic parts of the rock (See Fig. 1, p 199). Spec. 664. Magnified 37 diameters.

Fig. 2. *Red felsite-porphyry* (trachyte), showing feldspar in three generations; large phenocrysts, small rod-like crystals and small grains not well bounded. The glassy material has been changed to micro-felsite. The only other minerals are magnetite and secondary limonite replacing in part one of the orthoclase phenocrysts. Spec. 575. × 42 diam.

PLATE XIII.

Fig. 1. *Perlitic structure* in red felsite-porphyry (apobsidian) from Hammond River below Upham. The stippled part is microfelsite, which shows a flow-brecciated structure, the horizontal shading repre-

* And hence any rocks that they cut would be still earlier. They are very abundant in the intrusive granites near the city, and chiefly on this account the age of the granite was provisionally placed as pre-Cambrian. It seems well to make this point clear, as it has been mis-stated in a recent abstract of the article describing the granites.

sents secondary quartz and feldspar. The perlitic cracks are in fact preserved in a brightly polarizing substance, but this was not easy to represent in the drawing. × 67 diam.

FIG. 2. *Skeleton crystals of magnetite* in black felsite porphyry (petrosilex) from Hanford Brook. Spec. 570. × 67 diam.

PLATE XIV.

FIG. 1. *Diorite-porphyrite,* coarse grained. The hornblende is represented by heavy shading; the feldspar is lightly shaded. An attempt is also made to represent the zonal structure and decayed cores of the phenocrysts. The quartz is unshaded and the magnetite is dead black. Spec. 608. × 37 diam.

FIG. 2. *Diorite-porphyrite,* fine-grained. The shading is the same as in Fig. 1; it shows in addition a well marked flow-structure, and quartz as phenocryst; the quartz in the groundmass is not represented, nor are the feldspar individuals distinguished. × 30 diam.

PLATE XV.

FIG. 1. *Fine-grained Norite.* A phase of the olivine-gabbro at Dolin's Lake. Biotite is represented by heavy parallel lines, plagioclase by light ones; augite and hypersthene by irregular cracks, the hypersthene sometimes showing schillerization with innumerable minute parallel rods of magnetite. Spec. 473. × 77 diam.

FIG. 2. *Quartz-bearing diabase* from west of the Coldbrook Marsh. The feldspar is shaded with parallel lines, the augite by irregular ones, the magnetite being black and the quartz unshaded. The abundant apatite needles are too small to be shown in the figure. Spec. 304. × 20 diam.

PLATE XVI.

FIG. 1. *Soda-granite,* from Titus' Mill. The feldspar is stippled, the fine twinning of the anorthoclase, being represented where visible by parallel lines. Some attempt is made to show the comparative alteration of the feldspar by the heaviness of the stippling. Hornblende is represented by diagonally crossing parallel lines. Quartz is unshaded and magnetite is dead black. Spec. 661. × 18 diam.

FIG. 2. *Soda-granite* fine grained and porphyritic. From the Hammond River below Upham. Shading as in the last figure, but augite is represented by irregular lines. Spec. 666. × 37 diam.

PLATE XVII.

FIG. 1. *Granophyric structure* in soda-granite from near Hardingville. The feldspar is represented by parallel horizontal lines; the quartz is unshaded; the hornblende is represented by diagonally crossing lines, zircon by irregular heavy cracks, and chlorite by arrow points. In the upper left hand quadrant the quartz is mostly in minute trigonal prisms variously shown by different sections. In the upper right hand quadrant the quartz is regular and minute at the centre, but becomes coarse and irregular outside. In the lower half the quartz is seen radiating out from a crystal of feldspar, becoming coarser and more irregular as it continues its growth. The feldspar between these quartz growths is in part optically continuous with the central crystal. From Spec. 656. × 80 diam.

Stated Meeting.

April 22d, 1895.

The Academy met with Vice-president Stevenson in the chair, twenty persons present.

The minutes of the last meeting were read and approved.

The following persons were nominated for resident membership: R. A. Anthony, E. N. Dickerson and Henry Holt, and they were referred to the Council in the regular course.

Professor Martin moved that a committee be appointed to prepare a memorial minute regarding the recent death of Professor J. D. Dana, Honorary Member. The motion was carried and Messrs. Martin, Stevenson and Kemp were appointed.

The Section of Geology and Mineralogy then organized, and after a few introductory remarks by the Secretary, the following papers were presented:

W. D. Matthew, Sketch of the Igneous intrusions of New Brunswick, Nova Scotia and Newfoundland. T. G. White, Brief Outline of the Igneous Rocks along the Sea-coast of Maine and Massachusetts. J. F. Kemp, Sketch of the Igneous Rocks in the Province of Quebec, and the States of New York, Vermont, New Jersey, Pennsylvania and to the South.

The papers were designed to emphasize the igneous phenomena, especially of Palæozoic and later date and to show their frequency and importance along the Atlantic States and Provinces.

In discussion, Dr. E. O. Hovey reviewed the diabases and and granites of Connecticut, and the chairman mentioned his discovery of several boulders of feldspar-porphyry in a Chemung conglomerate of Fayette county, Penn., which indicated the presence of an undiscovered dike in western Pennsylvania.

The Academy then adjourned.

J. F. Kemp,
Secretary.

STATED MEETING.

April 29th, 1895.

The Academy met with President Rees in the chair, twenty persons present.

The Secretary presented the following nominations for resident membership: James B. Ford, 507 Fifth Avenue; Chester W. Chapin, 34 West 57th Street; Rev. E. A. Hoffman, D. D., 1 Chelsea Square; C. H. Coster, 27 West 19th Street; Charles H. Senff, Whitestone, N. Y.

The nominations were referred to the Council.

The Academy then listened to the Sixth Public Lecture of the Course for 1894–95, by Professor J. K. Rees, on Variations of Latitude. Forty persons were present.

J F. KEMP,
Recording Secretary.

STATED MEETING.

May 6th, 1895.

President Rees in the chair; 18 members and guests present. The following candidates having been nominated, and approved by the Council, were elected resident members of the Academy:

R. A. ANTHONY.	REV. E. A. HOFFMAN, D. D.
CHESTER W. CHAPIN.	HENRY HOLT.
C. H. COSTER.	HERSCHELL C. PARKER.
E. N. DICKERSON.	CHAS. H. SENFF.
H. DEFOREST EARLE.	FRANCIS LYNDE STETSON.
JAMES B. FORD.	HERBERT T. WADE.

The Section of Astronomy and Physics then organized with Professor R. S. Woodward in the chair.

There being no other business, after the minutes were read and approved, the Section listened to the paper of Dr. M. A. Veeder, of Lyons, N. Y., upon "Results of Observations of the Aurora and related Conditions."

A very large and valuable amount of data upon the Aurora, sun-spots, magnetic storms and electric storms was set forth, showing very beautifully certain periodic recurrences, as well as certain interesting facts as to local distribution and time distribution, *e. g.*; Aurora period, 27 days, 6 hours and 35 minutes, same as that of sun-spots and magnetic storms. Aurora and magnetic disturbance are simultaneous with the appearance of disturbances on the eastern limit of the sun. More Auroras occur near the equinoxes than the solstices. Thunderstorm activity may replace Auroral activity. Pennsylvania is predisposed in favor of, and Michigan against Aurora. One maximum is at 10 p. m., and a secondary maximum at 2 a. m., with a change in the sign of the disturbance at midnight. The author suggested possible explanations of these phenomena. The paper was discussed by Professors Rees, Pupin and Hallock.

Professor W. Hallock then told how in 1890 Dr. Hillebrand and himself undoubtedly had argon and helium in the gas given off by cleveite. They negatively identified them as nitrogen, although dissatisfied with the results. Press of official work prevented the desired complete examination of the gas at that time.

At ten o'clock the Academy adjourned.

WM. HALLOCK.
Secretary of Section.

STATED MEETING.

May 13th, 1895.

The meeting was called to order at 8:15, Professor Britton in the chair. Eighteen persons present.

In the absence of Dr. Bashford Dean, Secretary of the Section, the reading of the minutes of the preceding meeting was omitted, and C. C. Trowbridge was appointed by the Chair to fill the office of Secretary pro tem.

The Section of Biology at once organized. There being no business to be transacted, the Section listened to the first paper of the evening, "The Cervical Plexus of the Cynomorphus Apes," by Dr. G. S. Huntington, which had been deferred from the meeting of March 11. Remarks followed by Professors H. F. Osborn and E. D. Wilson. Professor Britton asked to be excused, and appointed Professor Wilson to act as Chairman.

Professor Osborn delivered his paper on "The Relations of the Fauna of the Uinta Basin," after which the Academy listened to the following:

OBSERVATIONS ON THE YOLK-NUCLEUS IN THE EGGS OF LUMBRICUS.

GARY N. CALKINS.

In 1845 v. Wittich described a peculiar body lying in the cell plasm of the immature spider-egg (*Lycosa*, *Tegenaria* and *Thomisus*), and to this body Carus in 1850 gave the name of "*Dotterkern*," or yolk-nucleus. In 1864 the origin and appearance of the yolk-nucleus was carefully studied by Balbiani, and this led Milne-Edward in 1867 to give it the name of "*Vesicule de Balbiani*." Later observers have reported the presence of a yolk-nucleus in the eggs of many different classes of animals besides the spiders. It has been observed in the eggs of myriopods, birds, amphibians, fishes, lizards, molluscs, elasmobranchs, mammals, crustacea, echinoderms, bees and other insects, and finally in some of the worms [Trematodes]. The yolk-nucleus appears, therefore, to be a structure of general occurrence in the early stages of oögenesis.

Many other names have been given to the yolk-nucleus. In addition to "*Vesicule de Balbiani*" of Milne-Edward, it has been called "*Nebenkern*," "archoplasm," "accessory nucleus," and "*Dotterkonkrement*." None of these, however, improve upon the original name Dotterkern which, after 45 years, is still in use. A more explanatory name might be given to the "yolk-nucleus," for it is not a nucleus, but on account of the priority and of the significance which it has acquired, the term given by Carus is here retained.

Nearly all observers agree as to the appearance and location of the yolk-nucleus in the egg. It consists of a heap of granules of greater or less size lying, at some period of oögenesis, near the germinal vesicle, but which may become disseminated throughout the egg. A central corpuscle about which the granules are arranged in concentric rings has been observed in some cases (Siebold ('48), Balbiani ('93), Henneguy ('93), but in most forms the yolk-nucleus is described as a mere aggregation of granules. Its origin has received much attention, but is still in doubt, some observers asserting that it arises from the nucleus and passes into the cytoplasm, while others maintain that it originates in the cytoplasm, and in some cases may even migrate into the nucleus.

The object of the present preliminary notice is to describe the origin and changes of the yolk-nucleus as observed in the developing eggs of the earthworm, *Lumbricus terrestris.* In order to bring these observations into relation with those of previous investigators it is necessary to examine more carefully the various contradictory views as to the origin and fate of this interesting body.

The works of various observers may be divided into two classes according as the yolk-nucleus is conceived to be of cytoplasmic or nuclear origin.

1. Cytoplasmic origin of the yolk-nucleus.

Lubbock ('61) regarded the yolk-nucleus as a mere thickening of the plasm forming the vitellus, and Balbiani ('66) regarded the yolk-nucleus in spiders as arising by budding from the epithelial tissue of the ovary. This view, however, he subsequently changed. Sabatier ('83) asserted, also in the spider, that the yolk-nucleus is formed in the cytoplasm in the neighborhood of the germinal vesicle, that it wanders to the periphery and there disintegrates. Stuhlmann ('86) regarded it as arising in insects from concretions close to the egg periphery and as not identical with the "maturation balls," which originate at the same time from the nucleus. Holl ('90) asserted that in the chick it arises as a mass of granules near the germinal vesicle, to which it may send out prolongations. Monticelli ('92) claimed that in the case of Trematodes there is no connection between germinal vesicle and yolk-nucleus and that the latter arises as a protoplasmic differentiation of the cytoplasm. Jordan ('93) came to a similar conclusion in regard to the yolk-nucleus of the newt.

2. Nuclear origin of the yolk-nucleus.

The extrusion of nuclear elements has been repeatedly described and by so many authors that it cannot in all cases be regarded as due to faulty preparations, although this appears probable in some instances. Fol ('77) was the first to note the throwing out of nuclear parts in the eggs of ascidians, observations which he confirmed in '83 and '84 on the eggs of other forms. According to his view, the nucleus gives rise to buds each of which contains a portion of the chromatin network. Balfour ('78) indicated in the eggs of mammals and elasmobranchs, a mass of granules which he believed were detached parts of the nucleolus. Shäfer ('80) in the fowl's egg observed that the yolk-nucleus was connected with the germinal vesicle by numerous fine striations. Balbiani ('83) claimed that in the Geophilidæ it originates by direct transposition of parts of the nucleolus of the germinal vesicle. Will ('84) claimed that in amphibians the entire nucleolus is cast out into the cytoplasm. Blochmann ('84) asserted that in hymenoptera the germinal vesicle buds, each bud containing some of the chromatin network. Scharff ('88) made a similar observation on fish eggs. Leydig ('88) saw the nucleolus in triton become amœboid and wander out into the cytoplasm where it finally broke up into granules around the periphery of the yolk. Van Bambeke ('93) asserted that in the eggs of *Scorpæna* the chromatin rods, as such, wander out into the cytoplasm although they were seen to undergo no change while there. Finally Henneguy ('93) and Balbiani ('93) found that in various eggs the yolk-nucleus originates from the nucleolus.

It is evident from the foregoing review that not only are there contradictions in regard to the nuclear or cytoplasmic origin of the yolk nucleus, but also that there are various opinions among those claiming nuclear origin. Fol ('84), Blochman ('84), Scharff ('88), and Van Bambeke ('93) asserted that it is a portion or portions of the chromatin network, while Balbiani ('83 and '93), Will ('84), Leydig ('88), and Henneguy ('93) maintained that it is a portion or the whole of the germinal spot or nucleolus. The question of the yolk-nucleus origin stands, therefore, in rather an unsatisfactory position.

The ovary of *Lumbricus* is small and therefore quite advantageous for the study of the yolk-nucleus, it being possible to get in one section all of the stages of oögenesis, from the epithelial cells at the base of the ovary to the nearly ripe eggs at the tip.

The earliest egg cells (oögonia) have no indication of a yolk-nucleus. They are small and contain large nuclei, the chromatin being in various stages preparatory to karyokinesis (fig 1.) In every ovary, not far distant from the base, there is a more or less complete zone composed of cells in the spirem stage of karyokinesis and with occasional spindle figures. Above this zone one never sees the yolk-nucleus, below it the yolk-nucleus can be found in all the stages of its development and disappearance. It first appears as a heap of closely aggregated granules at one part of the nucleus and so closely applied to the nuclear

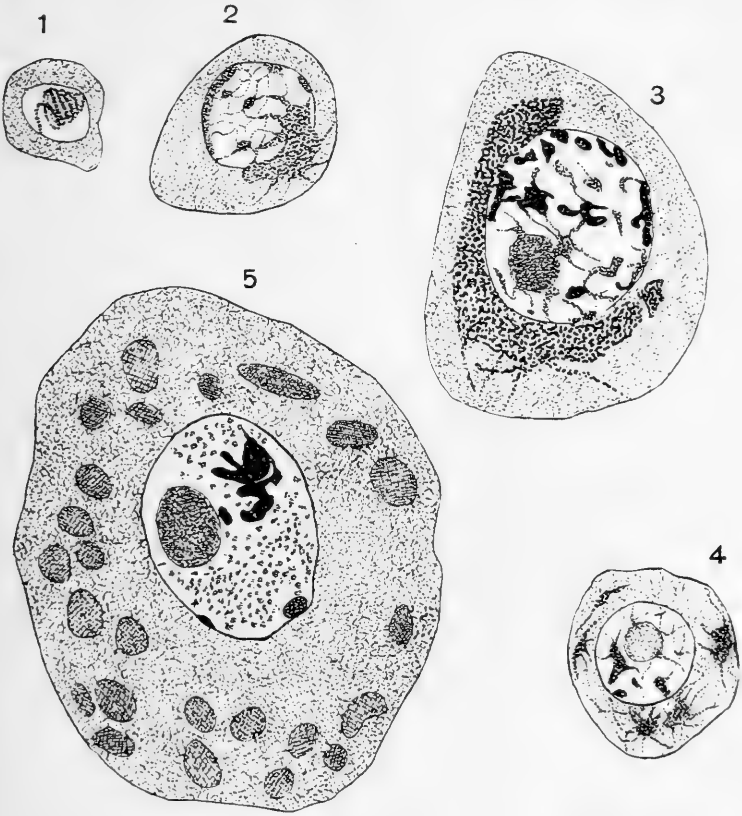

Fig. 1. Oögonium in the spirem stage.

Fig. 2. Oöcyte showing origin of the yolk-nucleus from the chromatin network.

Fig. 3. Later stage to show position of the yolk-nucleus, fibrous prolongations, and the beginning of disintegration.

Fig. 4. Later stage of disintegration.

Fig. 5. Nearly ripe egg, showing yolk plates, and disintegrated chromatin within the germinal vesicle. All camera drawings from sections.

membrane that the latter seems broken at this point. In many cases the granules lie partly without (fig. 2). In slightly older eggs the mass of granules—the yolk nucleus—is much enlarged but still lies close to the nucleus. At this stage many fibrous but granular processes can be seen extending out into the cytoplasm (figs. 2 and 3), while aggregates of the granules begin to break off from the main mass (fig. 3). This marks the disintegration of the yolk-nucleus. In older eggs the yolk-nucleus moves away from the nucleus, the disintegration continues, and the egg then contains a great number of smaller granular masses each with several fibre-like prolongations. At this stage the nucleus begins to enlarge and to change into the germinal vesicle. Next the disintegrated masses lose their granular structure and become large and homogeneous, forming the yolk plates of the egg (fig. 5). In all of these latter stages the nucleolus lies intact within the germinal vesicle (figs. 4 and 5).

The position of the yolk-nucleus on and near the nuclear membrane favors the view that it is of nuclear rather than of cytoplasmic origin; and the lack of a membrane at this portion of the nucleus adds strong evidence in favor of such an origin. A critical examination of the chromatin network inside of the nucleus leaves no doubt that such is the case. The yolk nucleus is in direct connection with the chromatin, not at one point only, as Van Bambeke pictures for *Scorpæna*, but at many points (fig. 2). In some cases one half or more of the yolk-nucleus lies inside of the nuclear membrane, while great strands of chromatin stretch from it to the opposite side of the nucleus. In other cases only two such strands will be seen, but in all cases there is direct connection between the granular mass outside and the chromatin mass inside.

As the yolk nucleus moves away from the nucleus all connections are broken between it and the chromatin. It appears as an independent body, while the nucleus regains its intact membrane and then begins its metamorphosis into the germinal vesicle. The yolk-nucleus does not again come in contact with the nucleus.

It appears, therefore, that in *Lumbricus the yolk-nucleus is not only of nuclear origin, but is derived from the chromatin, the nucleolus of the germinal vesicle taking no part in its formation.*

It does not appear thus far, however, whether the yolk nucleus is indirectly derived from the chromatin as a product of metabolic activity or whether it is directly derived by bodily disintegration of the chromatin. This question cannot be settled by examining the position of the yolk-nucleus. It is in direct communication with the chromatin network, it is true but a secretion from the chromatin might be similarly placed. In the other cases cited where the yolk-nucleus originates from the chromatin network there seems to be no doubt about its being true chromatin. Fol ('84) Blochmann ('84) and Scharff ('88), for example, asserted that portions of the nucleus containing parts of the chromatin network are budded off and that these parts become the yolk-nuclei. Van Bambeke ('93) claimed that the chromatin threads pass unbroken through pores in the nuclear membrane, although he is not satisfied that the eliminated part is a true yolk-nucleus. His figures leave little doubt on the subject, however, for the extra-nuclear chromatin is pictured as breaking up into granules which become ranged around the nucleus and in the cytoplasm of the egg in a manner similar to that so often described for a yolk-nucleus.

The most satisfactory answer to this question is afforded by the micro-chemical color reactions of the yolk-nucleus and the chromatin. As is well known, chromatin contains a large percentage of nucleic acid and has a marked affinity for basic stains. Cytoplasm, on the other hand, contains a great percentage of albumen with little or no nucleic acid and has an equally marked affinity for acid stains. If, therefore, the yolk-nucleus stains the same as does the chromatin, it may be inferred that it is composed of a similar substance. In Van Bambeke's figures of safranin preparations the mass of granules and the chromatin are the same color, and as he asserts and pictures the granules as coming directly from the nuclear network one can only conclude that they also are chromatin.

The micro-chemical reactions on the egg cells of *Lumbricus*, as shown by differential staining, reveal two facts: first, the mass of granules around the nuclear membrane stains the same as the *chromatin*; second, the disintegrated parts of the yolk-nucleus in the older eggs, as shown in figure 5, stain the same as the *cytoplasm*. These differences can be seen in the same section, so that the criticism of different treatment cannot be sustained.

The combination stain of Heidenhain's hæmatoxylin and orange makes the chromatin and the yolk-nucleus a blue-black, while the nucleolus of the germinal vesicle and the cytoplasm are orange. The Biondi-Ehrlich mixture stains the young yolk-nucleus a bright *green*, while in the older eggs the disintegrated yolk-nucleus is stained a bright *red*. The principal constituents of the Biondi-Ehrlich mixture are methyl green (basic) and acid fuchsin (acid). To remove all doubt in regard to the chemical action of these colors a solution was made containing basic fuchsin and acid green (Lichtgrün). The result was a reversal of the colors—the chromatin and yolk-nucleus were stained red and the cytoplasm green. Other differential stains were used and all gave similar results. After Flemming's triple stain the yolk nucleus and chromatin were purple; the cytoplasm and nucleolus had an orange tint. After borax carmine and Lyons blue the yolk-nucleus and chromatin had the bright red stain of the carmine.

The only conclusion that can be drawn from these experiments and from the morphological evidence of the origin of the yolk-nucleus is that this element of the egg cell of *Lumbricus* originates *as chromatin.* The micro-chemical reactions, however, show that it does not retain the chemical composition of the chromatin. As the egg grows and as the yolk-nucleus disintegrates, the several parts gradually lose their affinity for the nuclear stains, and gradually acquire that of the cytoplasm. In some stages the parts of the yolk-nucleus have no definite stain, while in one or two cases some portions of the disintegrated body were stained with the cytoplasmic colors, while others in the same egg were colored like the nucleus.

One other observation remains to be noted. As the eggs develop into the germinal vesicle stage, the nucleus gradually becomes filled with minute particles which stain like the cytoplasm, while the chromatin is aggregated into rather a dense mass at one part of the germinal vesicle (fig. 5). These particles within the nucleus acquire the cytoplasmic stain at the same stage as the parts of the yolk-nucleus and it is probable that they are of the same substance.

To conclude with a few words regarding the fate of the yolk-nucleus. Thompson ('59), Waldeyer ('70) and Legge ('87) thought that it disappeared completely before the egg is ripe. Scäfer ('80) asserted that it entered into the formation of the follicle cells. Jatta ('82), that it became evenly distributed over the egg. Iijimi, that it served as nutritive material (yolk). Korschelt ('89) maintained that it breaks up into small balls, which wander into the germinal vesicle. Jordan ('93) thought that it serves as food substance. Lavdowsky ('94) held that the yolk plates are taken bodily into the nucleus where they form chromatin. In *Lumbricus* the yolk-nucleus disintegrates, and the parts become homogeneous in appearance, and then enlarge to form the great yolk plates.

The results of these observations on the yolk-nucleus may finally be thus summarized: The yolk-nucleus is chromatin in the form of a mass of granules; this granular mass disintegrates and the parts form the yolk plates of the egg after undergoing change in their chemical composition.

Columbia College, May, 1895.

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The paper was discussed by Professors Osborn and Wilson.

The fourth paper followed, entitled "Induced Forms of Development of Ilyannassa," by H. E. Crampton, and was discussed by Professor Wilson, who had taken part in the investigation.

The last paper of the evening was read by C. C. Trowbridge, on "Hawk Flights in Connecticut," illustrated by lantern slides, showing the principal species of the *Falconidæ* found in the flights in Connecticut.

The meeting then adjourned at 10:15.

C. C. TROWBRIDGE,
Secretary pro tem. of the Biological Section.

NOTE.—References preceded by asterisk (*) are referred to from reviews by Henneguy ('93) Balbiani ('93) Jordan ('93) Carus ('50) (for v. Wittich).

THE SIGNIFICANCE OF MUSCULAR VARIATIONS, ILLUSTRATED BY REVERSIONS OF THE ANTI-BRACHIAL FLEXOR GROUP.

By Geo. S. Huntington.

Read by Title, Feb. 11, 1895.

The study of muscular variations, if carried on systematically, embracing observations made on a large number of subjects, cannot fail to reveal certain finer differentions, which, while lost in a mere enumerative record of muscle variations, gain a new and important significance when grouped together and compared in an effort to trace the morphological meaning of the variant condition. This becomes most strikingly apparent in the case of certain appendicular muscles, and especially of some muscles of the fore-limb. The extreme modifications which, in vertebrates possessing an anterior extremity, widely different functional requirements have impressed on this portion of the locomotory apparatus, may properly be held responsible for the fact that here variations of the most composite type are to be encountered. A glance at the divergent forms presented by the vertebrate pectoral girdle will convince us that the muscular structures connected with the same must offer deviations from the primitive types, which not only change the arrangement of homologous muscles in different forms, but which will afford the opportunity for numerous reversions to the original condition in the case of any individual muscle.

The specialization of the fore-limb, in exchanging a purely or chiefly locomotory function for one which includes or substitutes the prehensile function, and the consequent higher development of the manus, has more especially served to single out the anti-brachial flexor group, and to add to the function of flexing the forearm at the elbow-joint the more complicated movements of radial rotation in supination of the hand. In some instances this additional functional requirement has sufficed to specialize certain members of the flexor group as supinators, modifying the insertion so as to restrict the same chiefly or entirely to the radius, and separating a portion of the flexor mass by complete cleavage from adjoining muscular strata.

This is most excellently seen in the so-called Biceps flexor cubiti of Man and Primates generally, a muscle which acts as one of the chief radial supinators, while its flexor function is to a considerable extent subordinated to this main action.

In muscles of this type variations are frequently encountered, many of them being reversional in character and pointing to previous ancestral types of myotecture.

The definition, which certain muscular attachments obtain by specialization of function, is accompanied by the concomitant reduction or elimination of other connections which have lost their original value and significance in the new sphere of the muscle, or would even, if retained, interfere with the same.

The muscle, in returning in an incomplete form to these obsolete conditions, presents reversions to which many of the observed variations may properly be ascribed.

No muscle presents these features more strongly developed than the Biceps flexor cubiti. The muscle is, next to the Palmaris longus, the most variable in the body, Macalister* in his Catalogue of Muscular Anomalies enumerating no less than 45 separate variations.

It is our purpose in the present paper to discuss only a certain group of these variations, and to endeavor to obtain an insight into their significance.

The human material, on which the following observations have been made, consists of 464 upper extremities dissected during the year 1893 to 1894 in the Anatomical Laboratory of Columbia College.

As the explanation of the probable derivation and significance of certain of these variations of the Biceps muscle is closely connected with the morphology of the remaining antibrachial flexor group, it will be desirable to take a general view of the arrangement of this group, before proceeding to the details.

In the lowest vertebrates a continuous and non-segmented plane of muscular fibres proceeds from the ventral aspect of the trunk to the flexor surface of the anterior limb. This condition is best represented by the muscular apparatus of the pectoral fin in fishes.

In ascending the scale differentiation leads to the more or less complete separation of this muscular mass into layers and strata, which may or may not preserve connections with each other, indicative of their original union.

A consideration of the general arrangement of the flexors of the forearm in higher vertebrates reveals the existence of three main divisions or layers,† more or less blended with each other.

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*Alexander Macalister, Additional Observations on Muscular Anomalies in Human Anatomy (III. Series), with a Catalogue of the Principal Muscular Variations hitherto published. Transact. of the Royal Irish Academy, Vol. XXV., Pt. I., Dublin, 1872.

† G. M. Humphry, Observations in Myology, Cambridge and London, 1872, p. 163.

1. *Superficial layer*, a portion of the superficial ventro-appendicular muscular sheet, reaching, usually by combination with the succeeding layer, a skeletal or fascial insertion in the forearm. Usually but few and unimportant traces of this layer are found in higher forms, the great bulk of the superficial fibres passing from the trunk to the anterior extremity terminating, as Pectoralis Major and Latissimus dorsi, respectively on the radial and ulnar margin of the humerus. Occasionally, however, the Pectoralis Major is not arrested at the radial tubercle of the humerus, but, as in Orycteropus, accompanies the Biceps to the radius, or, as in the Otter and Wildcat, together with some fibres of the Trapezio-Deltoid, accompanies the Brachialis anticus to the ulna, or, as in the Seal, expands into the fascia of the forearm and thus reaches the hand.*

2. *Intermediate layer*, constituting the "extrinsic" limb muscles of Humphry, derived from the deeper portion of the ventro-appendicular sheet, forming muscles arising from the pectoral girdle and passing over the elbow to the bones of the forearm. This group is represented by the Biceps, which muscle, besides its relation to the Coraco-humerals, presently to be considered, presents various degrees of continuity with, and separation from, the following layer.

3. *Deep layer*, formed by the "intrinsic" limb muscles, arising from the humerus, and pursuing the same course as the 2nd layer, represented by the Brachialis anticus, or in some instances (Hippopatamus) by the Brachio-radialis†, which muscle in this animal is larger and occupies the space on the outer side of the humerus from which the Brachialis anticus usually arises.

Here we meet with a replacement of the usual Brachio-ulnar by a Brachio-radial flexor, to the complete exclusion of the former.

The 2d and 3d layers, *i. e.*, Biceps and Brachialis anticus, either considered by themselves, or more especially when viewed in the light of their mutual relation, present many points of morphological interest, and suggest explanations of human revisional variations of the former muscle.

A general review of the conditions found in the anti-brachial flexor group will call for the consideration of the following points:

I. *Morphology of the Biceps, the variations of the muscle and their significance.*

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* Humphry, op. cit., p. 147.

† Humphry, op. cit., p. 163.

II. *Relations of Biceps to the adjoining deep ventro-appendicular muscles, viz.: the Coraco-humerals.*

III *Relations of Biceps to the deep intrinsic flexor of the forearm, viz.: the Brachialus anticus.*

I. Morphology of the Biceps Flexor Cubiti.

We may in the first place consider the composition of the human Biceps in the light derived from the comparative study of the muscle in other vertebrates.

Although our knowledge of comparative myology is still somewhat meagre, considering the extent of the subject, and although the results of investigations appear at times too fragmentary and uncertain, yet enough is known to justify us in regarding the form in which the Biceps usually presents itself in man as the result of certain specializations of function acquired by the upper extremity, which have brought about a greater definition of certain portions, whereas other parts, lacking the stimulus of this functional requirement, have retrograded and have become to a great extent rudimentary or entirely eliminated.

A. Origin.

In the complete form the Biceps occupies two points of origin from the shoulder-girdle corresponding to the anterior edge of the glenoid socket and to the coracoid element.

The actual arrangement of the muscle in individual forms will be naturally greatly influenced by the structure of the girdle, and notably by the predominance or reduction of the coracoid and its appendages. An instance of this is afforded by the extensive Coraco-radial muscle which represents the Biceps in Cryptobranchus japonicus, whereas, in many other forms, the coracoid origin of the muscle is much reduced or absent, and the Biceps appears as arising solely from the glenoid margin.

A glance at the arrangement in the vertebrate series will immediately indicate that the origin of the muscle is confined, strictly speaking, to the coracoid element of the pectoral girdle. It may arise by a single head, or, as in man, the origin may be double, hence the name.

If, as in us, the coracoid is reduced and the scapula correspondingly increased, the muscle, if it preserves its double origin, will arise by one head from the small coracoid process, by the other from that portion of the glenoid margin which is contributed by the coracoid bone. If the long tendon of the glenoid head of our Biceps is examined in subjects between the ages of ten and puberty, it will be found in every instance connected with the so-called sub-coracoid centre of ossification.

Hence our division of the muscle into glenoid or scapular, and coracoid heads, while convenient as corresponding to adult conditions, should not cause the fact to be forgotten that the Biceps is entirely a coracoid muscle in in its origin. We might, considering the probable significance of our coracoid ossification, speak of the coracoid or long and precoracoid or short head of the muscle. The origin of the Biceps taking place in this manner from a single skeletal element, it is not surprising to find the consolidation of the two heads, which are present in man and the primates generally, to be of very frequent occurrence in lower forms. It will then depend upon the prominence of the coracoid element, and the relation of the origin to the glenoid socket, whether this single head will be denominated as the coracoid or glenoid muscle.

B. Insertion.

In like manner we find a considerable range in variation in the insertion of the muscle. It may be attached to either or both bones of the forearm, according to the functional character of the limb, and the specialization of rotatory radial movements of the forearm and hand. Moreover, in forms presenting the origin by two heads from the pectoral girdle, either or both of the girdle heads may be connected with either, or, by division of the insertion, with both of the forearm bones.

Consequently the analysis of the Biceps muscle would result as follows, retaining the names "glenoid" and "coracoid" as designating respectively the outer and inner girdle origins of the muscle:

Complete type form of muscle, four heads.

1. Gleno-radial.	*3. Coraco-radial.*
2. Gleno-ulnar.	*4. Coraco-ulnar.*

This type becomes modified in various forms by reduction and elimination of two or more heads, so as to present a number of variations. Krause* first pointed out this quadricipital character of the human Biceps, based on careful dissection of the muscle and analysis of the fibres at the insertion. He also collected a number of comparative anatomical facts in support of this view of the compound character of the muscle. A by no means exhaustive consideration of the structure of the Biceps in the lower animals reveals the existence of the following reduc-

*W. Krause, Specielle und Macroscopische Anatomie, Hanover, 1879, p. 223.

tions and combinations of the four type heads of origin and their insertion.

I. *Gleno-radial alone.*

A typical instance is presented by Talpa europea. Geohegan * describes the muscle in this animal as follows: The Biceps is single-headed, arising just above the glenoid articular surface by a long tendon which passes through a groove in the extreme anterior end of the humerus; this groove is at first a tunnel. It is only after it has passed the elbow that the muscle becomes fleshy. Insertion below the middle of the radius. Welcker † corrects this statement to read that the insertion is above the middle of the radius.

Other forms presenting the Glenro-radial muscle are: Nyctipithecus, Stenops, Horse, Ruminants,‡ Lutra vulgaris.§

II. *Coraco-radial alone.*

This form of the Biceps muscle is presented by Orycteropus capensis, Rhinoceros, Frog, Toad, Lacerta, ‖ Phoca vitulina.¶ In this animal the muscle arises from the coracoid process, is inserted into the radial tuberosity, and is combined with a short head, which is connected with the Brachialis anticus.

III. *Gleno-ulnar alone.*

The muscle occurs in this form in Hyrax capensis and in Rodents generally.**

IV. *Coraco-ulnar alone.*

Humphry,†† in describing the muscular system of Cryptobranchus japonicus gives the following account of the Coracobrachialis longus.

"This is the largest muscle arising from the coracoid. It arises from the hinder edge of the coracoid and divides into two portions. Of these the larger and inner or lower division is inserted into the ulnar edge of the humerus for a quarter of an inch above the internal condyle; the other division, being nearly

*Geohegan, Myology of the Fore-limb of Talpa europea, Proceedings Dublin Biolog. Assoc., Vol. I., 1875, p. 5.

†Welcker, H., Archiv f. Anatomie und Entwicklungsgeschichte, 1878, p. 23.

‡ Krause, op. cit., p. 223.

§ Lucae, J. C. G., Die Robbe und Otter (Phoca vitulina und Lutra vulgaris) in ihrem Knochen und Muskelskelet, Frankfurt a/M, 1873, p. 204.

‖ Krause, op cit., p. 223.

¶ Lucae, op. cit., p. 199.

** Krause, op. cit., p. 223. W. Krause, Anatomie des Kaninchens, p. 107.

†† Op. cit., p. 33.

as large, is partly inserted into the side of the long tendon of the Biceps, while a bundle of its fibres is continued on over the elbow, and is inserted into the ulna near the joint. The last described division must represent the short or coracoid origin of the Biceps in man. There is no trace of it in Menobranch, Axolotl or Newt. The muscle in them, though large, is confined to the humerus in its insertion."

The Coraco-radialis or Biceps arises from the external surface of the coracoid, between the Epicoraco-brachial (Pectoralis minor) and the short Coraco-brachial, as a fan shaped muscle, the fibres of which pass across the short Coraco-brachial and soon converge into a long tendon, which runs down beneath the Pectoral. Having passed the Pectoral it receives the fibres of the long Coraco-brachial, passes over the elbow joint, and is inserted into the palmar surface of the upper end of the radius close to the joint. It is supplied by the nerve which perforates the scapula and which supplies also the superficial Coraco-brachial.

V: *Gleno-radial and Coraco-radial.*

Meckel * describes the double-headed Biceps of Ornithorrhynchus paradoxurus, one head arising from the anterior, the other from the posterior coracoid, the muscle passing to be inserted into the radius.

VI. *Gleno-radial and Gleno-ulnar.*

Dog.

Origin: By a single strong tendon from the edge of the glenoid fossa, the tendon passing through the capsular ligament of the joint.

Insertion: By a strong tendon chiefly into the ulna, although attached also to the radius by a smaller slip.

Other forms presenting the same arrangement of the muscle:

Cholœpus didactylus.†

Two-toed sloth.

Origin: By a long and strong tendon from the glenoid border of the scapula, passing down through the intertubercular groove in the capsule of the shoulder. The muscle descends on the arm, dividing into two strongly developed bellies, one passing with the Pectoralis and Deltoid to the tuberosity of the radius, the other with the Brachialis anticus to the coracoid process of the ulna.

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*System der Vergleichenden Anatomie, p. 516.

†Lucae, J. C. G., Der Fuchsaffe und das Faulthier (Lemur macaco and Choloepus didactylus) in ihrem Knochen-und Muskelskelet, Frankfurt a/M, 1882.

The combination of gleno-radial and gleno-uluar muscle is also noted in the Pig and Cat.

VII. *Gleno-radial and Coraco-ulnar.*

Uromastix spinipes.*

Origin: by two distinct portions from coracoid, one tendinons from proximal part, the other muscular more laterally from anterior part, corresponding with the coracoid and glenoid origins in man.

Insertion: After being joined by Brachialis anticus, which is large, arising from the lower part of the humerus, the conjoined tendon is inserted into the radius and ulna.

VIII. *Coraco-radial and Gleno-ulnar.*

In Marsupials, in which the two muscles are entirely separate from each other.†

IX. *Coraco-Radial and Coraco-Ulnar.*

This arrangement of the muscle is found in Emys and Chameleon.‡

A general consideration of the facts above adduced leads to the natural conclusion that the Biceps muscle of the fore-limb, or its homologue, presents throughout the vertebrate series evidences in its structure and arrangement of a general type-plan of construction, modified in the different groups by the functional requirements of the limb, and in all probability by the varying relations assumed by the tendon of origin to the capsule and the cavity of the humero-scapular articulation. I believe that this fundamental type-construction of the appendicular muscular system is the element to which we must refer for the explanation of deviations from the arrangement normally found in any one species. Partial returns to the potential type-form constitute reversions of far broader significance than those usually grouped under the head of atavism.

In respect to the human subject, as well as in the case of the remaining vertebrates, and especially mammalia, our exact knowledge regarding the lines of descent of present orders and sub-orders is still so rudimentary and imperfect, that the impropriety of referring nearly all muscular variations to atavism and direct inheritance becomes at once apparent. The fact that

*Humphry, op. cit., p. 64.

†Krause, op. cit., p. 223.

‡Krause, op. cit., p. 223.

in case of any given human muscular variation, a muscle of similar character is found in one of the lower vertebrates does not warrant the assumption that both are derived by inheritance from an immediately precedent common ancestral form. The form in which the variant human muscle appears normally may be incalculably far removed from man, may even belong to a different vertebrate class. That the structural coincidence of the two muscles is to be taken as indicating anything more than the most generalized relationship of vertebrates is difficult to believe. For many of the aberrant muscular conditions observed in man a very comprehensive view as to their derivation must be adopted. I believe that we are right in referring such variations, as will be considered in detail below, to the development of an inherent constructive type, abnormal for the species in question, but revealing its morphological significance and value by appearing as the normal condition in other vertebrates.

The question, as far as it affects the variations to be considered, may be represented graphically somewhat in the following manner:

FIG. 1. Type form of Muscle.

FIG. 2. Cleavage variation.

In Fig. 1 let the line *a–b* represent the skeletal origin, the line *x–y* the corresponding insertion of a muscular plane. Considering this arrangement as the type, in which the entire space between origin and insertion is occupied by an uninterrupted muscular plane, it will become apparent that modifications of this type can take place in two ways.

1. Cleavage variations, retaining in general the original scope of origin and insertion, in which the original muscular plane appears as two or more distinct muscles. (Fig. 2.)

2. Reduction variations, where a portion of the origin or of

FIG. 3. Reduction variation; Origin retained; Insertion reduced.

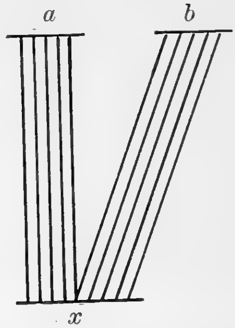

FIG. 4. Reduction variation; Origin retained; Insertion reduced.

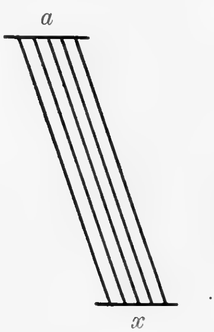

FIG. 5. Reduction variation; Origin and Insertion reduced; Points retained.

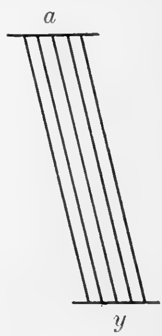

FIG. 6. Reduction variation; Origin and Insertion reduced; Points exchanged.

FIG. 7. Reduction variation; Origin and Insertion reduced; Points retained.

FIG. 8. Reduction variation; Origin and Insertion reduced; Points exchanged.

FIG. 9. Reduction variation; Origin reduced; Insertion retained.

FIG. 10. Reduction variation; Origin reduced; Insertion retained.

the insertion, or of both, is eliminated, necessitating, under some conditions, a change in the direction of the muscular fibres.

These variations are represented schematically by Figs. 3–10, it being of course evident that the arbitrarily selected points *a* and *b*, and *x* and *y*, may be placed anywhere along the lines of origin and insertion respectively.

In defining the following variations in the human Biceps I prefer to accentuate this relation to a fundamental vertebrate type-plan, and, at the expense of introducing an additional term into the complex reversional nomenclature, I will speak of them as "*Myo-typical Reversions.*"

In man the Biceps is composed of the Gleno-radial and Coraco-radial divisions, combined with a superficial ulnar fasciculus, possessing a fascial insertion along the ulnar border of the fore-arm by means of the semilunar fascia.

We may group the variations which concern us here with reference to the derivation and destination of the accessory portions, representing additional glenoid and coracoid heads, which have lost their distal ulnar attachment.

I. GLENO-ULNAR HEAD.

Appears in the following forms:

1. CAPSULO-PECTORAL TENDON.

Diagnosis: Tendinous fibres in the form of scattered bundles, or more compactly arranged as distinct tendon-bands, arising in conjunction with the capsular ligament from the glenoid margin of the scapula, differentiating from the capsule at the upper border of the intertubercular groove and extending downwards over the long gleno-radial head, roofing in the bicipital canal and merging with the deep surface of the tendon of the Pectoralis major, or, in some instances, extending beyond the pectoral tendon to the deep fascia of the arm.

This is the most common form in which the variation presents itself.

Cases:

1. ♀, white, U. S., aet. 62. January 30, 1894.

Plate XVII. Right upper extremity:

A distinct tendon, imbedded in the capsule of the joint, overlying the intertubercular groove, covering the long bicipital tendon and passing to the deep surface of the Pectoralis major tendon, on which it spreads out in the upper third, terminating by interlacing with the pectoral tendon fibres.

Left upper extremity:

Presents the same slip, more strongly developed, extending nearly to the lower border of the Pectoralis major tendon.

Plate XVIII. Capsule between the tuberosities partly divided, to show the deep position of the tendon imbedded in the shoulder capsule, and indicating a tendency toward intra-articular immigration.

Plate XIX. The same joint opened from behind, with head of humerus removed. The thickened strand on the inner surface of the anterior wall of the capsule, just in front of the long Biceps tendon, is directly continuous with the fibres of the tendon slip.

2. ♂, Austria, aet. 65. October 11, 1893.

Plate XX. Right upper extremity.

Strong fibrous band arising from capsule over lesser tuberosity, and descending over long tendon of Biceps, connected with deep surface of Pectoralis major tendon, to the lower margin of which it extends.

A tendon band from anterior part of capsule passes to outer margin of short head, indicating tendency to subdivision of this head.

3. ♀. Germany, aet. 84. November 9, 1893.

Plate XXI. Right upper extremity.

Well marked strong fibrous fasciculus, extending from capsule of shoulder joint over the bicipital groove and contents to the deep surface of the Pectoralis major tendon. Some fibres merge with the pectoral tendon, while others continue below its inferior margin to join the deep fascia of the arm.

The left upper extremity of the same subject presents a transition to the form next to be described (Gleno-ulnar muscle). A strong tendinous band, incorporated at its origin in the capsule of the shoulder joint, passes downward, covering in the bicipital groove and attaching itself to the upper margin and deep surface of the Pectoralis major tendon. In part continuous with this tendon band, in part arising independently from the deep surface of Pectoralis tendon, four muscular slips arise, the two upper passing backward, the two lower downward, to incorporate themselves with the substance of the Biceps muscle. The bundles are all distinctly muscular in character.

The following additional instances, in which the above described band was present, were noted in the series:

4. ♂, U. S. white, aet. 38. December 27, 1893.

Small glenoid tendon slip joining deep surface of Pectoralis major tendon over the bicipital groove. Present on both sides.

5. ♀ Ireland, aet. 72. January 9, 1894.

Slip present on both sides.

6. ♂ Ireland, aet. 40. December 21, 1893.

Right upper extremity.

Large tendon band, arising from capsule external to long head of Biceps, inserted on deep surface of Pectoralis major tendon.

7. ♂ Ireland, aet. 32. November 28, 1893.

Right side.

8. ♂ Germany, aet. 54.

Large band on left side. Insertion confined to Pectoralis major tendon.

9. ♂ Germany, aet. 52. December 14, 1893.

Right side.

Very large tendon ½ inch wide, passing from glenoid margin interwoven with the capsule, to the united bellies of Biceps, with intermediate attachment to the deep surface of Pectoralis major tendon.

10. ♂ Ireland, aet. 40.

Both extremities.

Strong tendon from glenoid edge to deep surface of Pectoralis major tendon.

11. ♂ Italy, aet. 50.

Right side.

Very broad tendon slip, in part continued beyond Pectoralis tendon into the Biceps.

12. ♀, U. S., negro, aet. 24.

Left side:

Glenoid tendon to junction of heads of Biceps.

2. Gleno-Ulnar Muscle.

Occurs in three forms or variations:

(*a.*) *Origin identical with that of the Capsulo-pectoral tendon, passing downward and presenting a more or less close connection* *with the deep surface of the Pectoralis major tendon. Becoming muscular a short distance beyond the lower border of the Pectoralis tendon the slip passes obliquely inwards across the long head, fusing with its anterior surface and inner margin, or joining the outer margin of the short coracoid head.*

Cases:

1. ♂, U. S., white, aet. 24. November 29, 1893.

Plate XXII. Right side.

A strong shining tendinous band arises from the glenoid margin incorporated with the shoulder capsule. Passing down and emerging from beneath the edge of the coraco-acromial ligament, the tendon becomes closely connected with the deep surface of the Pectoralis major tendon, interlacing with its fibres at right angles, lying upon the long tendon of the Biceps and forming the main portion of the roof of the inter-tubercular groove. Toward the lower portion of the pectoral tendon the inner half of the slip gradually separates itself from the same and forms a small muscular belly which joins the outer margin of the short bicipital head near its junction with the long head. The outer portion of the tendon slip gradually passes deeper into the substance of the Pectoralis tendon, with which it is intricately interlaced. On the bottom of the inter-tubercular groove are several well marked longitudional tendinous bands, connected below with the tendon of the Pectoralis major; above they in part separate from the tendon, passing upward and inward and crossing at right angles the tendon fibres of Latissimus dorsi and Teres major; in part they go upward and outward, lying in the floor of the bicipital groove under cover of the long Biceps tendon.

A small third internal humeral head of the Biceps is present in the same arm, derived from the Coraco-brachialis insertion.

2. ♂, U. S., white, aet. 50.

Plate XXIII. Right upper extremity.

Tendon slip with intermediate attachment to deep surface of Pectoralis major tendon, arising in connection with capsular ligament from the glenoid margin, and passing to the inner border of the long bicipital head, at the line of junction with the short head.

3. ♂, Ireland, aet. 32. November 29, 1893.

Plate XXVIII. Left upper extremity of subject, whose right upper extremity presents the variation described under "b 2," Plate XXVII. *vidi ibid.*

4. ♂, U. S., negro, aet. 50. December 14, 1893.

Plate XXIV. Right side.

Tendon in part fused with deep surface of Pectoralis major tendon at the lower border of which a short muscular belly develops which joins the Biceps.

Between the long and short bicipital heads an additional tendon slip arises from the capsule, near the base of the coracoid process, and, passing down on the outer side of the short Biceps tendon, receives some upper fibres of insertion of a short Coraco-brachialis superior, and then joins the outer margin of the short Biceps head just before the latter meets the long head.

The left side of the same subject presents an instance of the next succeeding form.

5. ♂, Germany, aet. 52. December 14, 1893.

Very large accessory glenoid head, ½″ broad, passing to the united bellies of the Biceps. Upper tendinous portion very distinct and adherent to Pectoralis tendon.

6. ♀, U. S. white, aet. 23. January 30, 1894.

Plate XXV. Left upper.

Gleno-ulnar tendon connected but loosely with deep surface of Pectoralis major; leaves tendon of Pectoral as a distinct band at about the middle of its posterior surface and a short distance below the distal margin of the pectoral tendon, expands into a superficial broad and flat muscular belly, which descends upon the long bicipital head, lying in close connection with the outer margin of the coracoid head from which it is completely separable to a point midway between the lower border of the Teres major and Latissimus dorsi and the elbow. The fibres of this accessory head then join the coracoid head along its external border. About 3 cm. above the internal condyle the long head joins the tendon of insertion, developed on the deep and external aspect of the combined coracoid and accessory heads.

The bicipital fascia receives some superficial and oblique fibres (decussating) from the outer and anterior aspect of the radial tendon.

The right arm of the same subject presents a Gleno-epitrochlear slip (*vide infra*).

(*b*.) *Tendon of origin of Gleno-ulnar muscle is completely free from Pectoralis major tendon, under cover of which it lies.*

Cases:

1. ♂, U. S., negro, aet. 50. December 14, 1893.

Plate XXVI. Left upper extremity of subject whose right extremity is described under "a 4," Plate XXIV.

Long, distinct glenoid tendon, overlying long bicipital tendon, under cover of Pectoralis major, but not connected with the same. Becomes muscular opposite lower third of pectoral tendon and crosses over long bicipital head to join its inner margin at about the middle of the arm.

2. ♂, Ireland, aet. 32. November 29, 1893.

Plate XXVII. Right upper extremity. Under cover of insertion of Pectoralis major, a broad tendinous band descends over the intertubercular groove, derived from the shoulder capsule and covering the long tendon of the Biceps, to which it is connected by a thin but strong tendinous lamina. The lower portion of this band terminates in a broad muscular sheet, which turns inwards to join the medial margin of the long head.

A few scattered tendinous fibres descend obliquely from the capsule to the outer margin and anterior surface of the lesser head.

The left upper extremity of the same subject presents the gleno-ulnar slip with intermediate connection to the deep pectoral tendon. (Variety "a.") Plate XXVIII.

Here a strong tendinous band, arising from the intertubucular portion of the capsule, and connected with the upper part of the deep surface of the Pectoralis tendon, becoming free below, crosses obliquely over the long bicipital tendon to fuse with the inner margin of its muscular belly a short distance before the same is joined by the coracoid head.

A small tendinous bundle (Capsulo-intermediate fibres), arising from the coracoid portion of the capsule, accedes to the outer part of the coracoid head.

Insertion of Biceps in this arm: Radial tendon derived as usual from the deep surface of the combined muscle. Superficially some fibres pass from the outer part of the muscle across the radial tendon into the semilunar fascia, which is inserted by a forked process into the radial as well as the ulnar side of the deep forearm fascia.

c. Transition forms between "a" and "b," and variations.

Cases:

1. ♂, Ireland, aet. 53. March 16, 1894.

Plate XXIX. Left upper extremity.

Gleno-ulnar tendon slip, presenting a reduplication of the origin. The outer band is connected with the Pectoralis major tendon; the inner is free. They join opposite the middle of the pectoral tendon and develop a stout, muscular belly, which can be followed as far as the elbow, where a few of the deeper fibres pass into the inner margin of the radial tendon of insertion, whereas the remainder of the deep and all the superficial fibres of the accessory head, joined by some from the outer margin of the main muscle, pass inward into the bicipital fascia.

2. ♂, Ireland, aet. 35. March 14, 1894.

Plate XXX. Left upper extremity.

Gleno-ulnar tendon, double at origin, a portion passing into the pectoral tendon, the remainder into the outer margin of the short bicipital head and into the Coraco-brachialis, which muscle is strongly developed in its upper part.

3. ♂, Germany, aet. 64. October 14, 1893.

Plate XXXI. Right upper extremity.

Double glenoid tendon, the outer division giving off a branch to join the deep surface of the pectoral tendon. The tendons of origin then unite and form a muscular belly which passes down and in over the long bicipital head to join the deep surface and outer margin of the short head.

3. Gleno-epitrochlear Tendon.

Diagnosis: Origin as Capsulo-pectoral fibres from glenoid margin with capsule of shoulder. Connected with deep surface of Pectoralis major tendon at the lower border of which the fibres are gathered into a long, slender tendon which passes obliquely down and in, across the Biceps, brachial vessels and large nerves, to be inserted into the anterior part of the internal epicondyle.

The structure exhibited by this variation in its upper portion is such as to admit of no doubt of its identity with the fibres described above as Capsulo-pectoral and Gleno-ulnar with intermediate pectoral connection.

The lower long tendon with its epicondylar implantation represents, I believe, a rudimentary Gleno-ulnar muscle, whose insertion has been shifted to the internal epicondyle. The latter is a point frequently selected for the insertion of aberrant and rudimentary tendon slips, as instanced by the Dorso-epitrochlearis and Chondro-epitrochlearis muscles.

The supposition that the variation just mentioned and some of the previously described bicipital variations can be brought into connection with aberrant pectoral muscle or tendon slips is refuted by the constant connection with the capsule, and by means of the same with the glenoid margin of the scapula.

The pectoral varieties described as Chondro-humeral, Chondro-coracoid and Chondro-epitrochlear muscles are connected at times with the lower border of the pectoral muscle and tendon, but they are evidently derivatives from the pectoral plane, and never assume the characteristic relation to the deep surface of the pectoral tendon and shoulder capsule exhibited by the bicipital variations above described.

I have met with four well-marked instances of the Gleno-epitrochlear tendon in the series examined.

Cases :

1. ♂, Germany, aet. 66. January 11, 1894.

Plate XXXII. Left upper extremity.

Glenoid tendon, overlying long Biceps tendon and fusing with the under surface of the Pectoralis major tendon in its broad upper part. About the middle of the pectoral tendon this connection ceases, and the tendon bundle becomes narrower and more sharply defined. It remains tendinous throughout and passes obliquely downward and inward over the Biceps, median nerve and brachial artery to be attached to the anterior aspect of the internal epicondyle.

In confirmation of the view expressed as to the nature of this variation the right upper extremity of the same subject presented the Capsulo-pectoral slip, as a well-marked tendon, connected with the deep surface of the Pectoralis major; also a separate slender tendon from the coraco-acromial ligament to the outer margin of the short bicipital head.

2. ♂, Ireland, aet. 42. November 13, 1894.

Plate XXXIII. Left upper extremity.

A tendon from the glenoid margin, interwoven with the capsule of the shoulder joint, passes over the long Biceps tendon, covered by the Pectoralis major tendon, to the deep surface of which it is partially attached, and continues beyond the pectoral tendon as a slender but very distinct band, passing obliquely downward and inward over the brachial artery and the large nerves to the internal epicondyle, blending with the lower quarter of Struther's ligament.

3. ♂, Germany, aet. 66. January 11, 1894.

Left upper extremity presents exactly the same arrangement.

4. ♂, U. S., white, aet. 23. January 30, 1894.

Right upper extremity.

Gleno-ulnar fibres, rather weak in upper portion, on posterior surface of Pectoralis major tendon.

From the lower part of the posterior surface of pectoral tendon, and from inferior border of deep reflected part, fibres are derived which form a slender tendon, passing down and in, superficial to and obliquely across Biceps and brachial vessels and nerves, to be inserted on the anterior surface of the internal epicondyle.

4. M. Brachio-ulanris lateralis.

I have placed under this designation certain of the variations of the Biceps, constituting accessory third humeral heads, arising from the anterior or external surface of the shaft, because a careful examination affords grounds for regarding them as distal portions of a Gleno-ulnar muscle, which has lost its proximal or origin portion, represented by the variations just described, and has obtained a secondary attachment to the humerus near the bicipital groove and the insertion of the Pectoralis major.

This group would therefore form the last of a series of variations of a muscle arising from the glenoid margin and finding its insertion at the ulnar border of the forearm.

Cases:

1. ♀, Ireland, aet. 27. October 25, 1893.

Plate XXXIV. Both upper extremities present the same variation.

A third additional Biceps head arises from the outer surface of the humeral shaft and capsule of the shoulder joint, and from a strong tendinous band into which the upper fibres of a Coraco-brachialis brevis are inserted.

The connections with the shoulder capsule, found in the Capsulo-pectoral, Gleno-ulnar and Gleno-epitrochlear variations, is retained in this instance as one of the points of origin of the accesssory head.

2. ♀, U. S. negro, aet. 24. December 27, 1893.

Plate XXXV. Right upper extremity.

A third bicipital head arises from the anterior surface of the shaft of the humerus, almost directly continuous with the lower margin of the Pectoralis major tendon and attached to the lower portion of the bicipital groove.

The muscle passes down on the outer side of the arm, separated from the upper and outer portion of the Brachialis anticus by some branches of the musculo-cutaneous nerve and muscular arterial branches. It then turns inwards beneath the main muscle to join the common tendon on the deep aspect and along the ulnar margin.

5. Combination of Capsulo-pectoral or Gleno-ulnar with Gleno-epitrochlear fibres.

Case:

♂, U. S., white, aet 23. January 30, 1894.

The two extremities present the variations already described as follows:

Right upper. Gleno-epitrochlear tendon (No. 4).

Left upper. Gleno-ulnar muscle, "a," No. 6, Plate XXV.

6. Combination of Tendinous Gleno-ulnar and Coraco-Epitrochlear.

Case:

♀, Ireland, aet. 72. January 9, 1894.

Plate XXXVI. Right upper extremity.

A slightly marked tendinous gleno-ulnar slip passes from the capsule of the shoulder over the intertubercular groove, with intermediate attachment to deep surface of pectoral tendon, to the angle of union between the long and short bicipital heads.

From the anterior surface of the lower part of the Coraco-brachialis, near its insertion, is derived a slender muscle-slip, which, becoming tendinous, passes obliquely down and in over brachial vessels and median nerve to be attached to the internal epicondyle.

The left upper extremity of the same subject presents a small tendinous band passing from the capsule to the deep surface of the Pectoralis major tendon.

II. Coraco-Ulnar Head.

This muscle is found usually very closely fused in its proximal part with the short or corao-radial head of the Biceps, and with the Coraco brachialis. But its distal portion appears frequently as the "*third internal humeral head.*"

The following variations are to be noted:

1. Capsula-intermediate Tendon.

Origin: Tendon fibres derived from the capsule of the shoulder joint between the coracoid process and bicipital groove. The slip passes down to the angle of fusion between the long and short heads of the Biceps.

Cases:

In combination with capsulo-pectoral fibres in the following previously described instances:

1. ♂, U. S., negro, aet. 50. December 14, 1893.

"2[a]," No. 4. Plate XXIV. Well marked on right side.

2. ♂, Ireland, act. 32. November 29, 1893.

"2[b]," No. 2. Plate XXVII. Especially well marked on left side.

3. ♂, Germany, aet. 66. January 11, 1894.

Right upper extremity. "3" No. 1.

Additional cases.

4. ♀, Italy, aet. 30. October 31, 1893.

Both upper extremities.

A strong fibro-tendinous band arising from the inner part of the capsule of the shoulder passes vertically down to be attached to the septum between the long and short Biceps heads.

5. ♂, U. S., white, aet. 27. December 31, 1893.

Right upper extremity.

Slender tendon from inner part of shoulder capsule to outer margin of lesser bicipital head.

Macalister * describes several varieties of additional coracoid heads of the Biceps (catalogue numbers 11–14 incl.). The accessory portion may join the main body of the muscle, or else it may unite with the normal coracoid head, before that portion of the Biceps joins the long head. Additional coracoid origins from the Coraco-acromial ligament and from the insertion tendon of the Pectoralis minor are also mentioned by the same author.

2. CORACO-EPITROCHLARIS.

As in the case of the Gleno-ulnar head certain instances occur in which an additional coracoid head passes to the internal epicondyle. I have met this arrangement in two forms :

a. Coraco-epitrochlear tendon.

Cases :

1. ♂, U. S. white, aet. 47. March, 1894.

Plate XXXVII. Right upper extremity.

A slender, firm tendon arises from the coracoid process at the inner border of the short bicipital head and superficial to the Coraco-brachialis origin. It passes downward and slightly inward obliquely over the brachial artery and the large nerves, receives near the elbow an accession of fibres from the internal intermuscular septum, and is inserted into the internal epicondyle.

2. ♂, Ireland, aet. 63. November 14, 1894.

Right upper extremity :

A thin tendinous slip arises from the intermuscular septum betwteen the short head of the Biceps and the Coraco-brachialis, passes downward and inward, over the musculo-cutaneous nerve to the internal epicondyle.

The musculo-cutaneous nerve passes entirely below the Coraco-brachialis, between this muscle and the short bicipital head, the former receiving its nerve higher up by a separate branch from the outer cord of the brachial plexus.

3. ♂, U. S. white, aet. 34. February 1, 1894.

Left upper extremity :

A tendon slip arises from the coracoid process and tendon of origin of the Coraco-brachialis and short bicipital head ; becoming free about 2 cm. below the coracoid it passes downward and inward as a distinct tendon to be inserted into the internal epicondyle.

4. ♂, U. S. white, aet. 39. December 14, 1893.

Left upper extremity :

A tendon slip from origin of Coraco-brachialis and short head

* Op. cit., p. 80.

of Biceps crosses over the brachial vessels and the nerves to the internal epicondyle.

The long tendon of the Biceps in this arm is doubled.

5. ♀, Ireland, aet. 72. January 9th, 1894.

Combined with tendinous Gleno-ulnar band in right arm (vide I. 6, Plate XXXVI).

b. Coraco-epitrochlear and Gleno-epitrochlear tendon combined.

Case:

♂, U. S., white, aet. 46. November 11, 1893.

Plate XXXVIII. Right upper extremity.

A coraco-epitrochlear tendon, arising from Coracoid process at point of junction between Coraco-brachialis and short bicipital head, passes down as above described over the brachial vessels and the large nerves, and is joined at about the middle of the arm by a second similar tendon which arises from the outer portion of the capsule of the joint, descends beneath Pectoralis major tendon and then crosses obliquely down and in over the short bicipital muscle. The conjoined tendons continue downward in the line of the Internal intermuscular Septum and are inserted as a single band into the internal epicondyle.

c. M. Coraco-epitrochlearis.

Case:

♂, Germany, aet. 29. January 11, 1894.

Plate XXXIX. Left upper extremity.

A slender superficial tendon arising from the coracoid process develops a thin fusiform muscle at about the middle of the arm, which passes down to the internal epicondyle, lying upon the brachial vessels and the large nerves.

The obvious connection of the Coraco-epitrochlear variations first described with the Coraco-brachialis inferior will be considered in dealing with the relation of the Biceps to that muscle.

3. M. Brachio-ulnaris Medialis.

Under this head I have placed the variations which include a third bicipital head, arising from the inner surface of the shaft of the humerus, either from the interval between the Coraco-brachialis and Brachialis anticus, or directly from the latter muscle, or from the insertion of the Coraco-brachialis and continuous with that muscle.

It has seemed to me, in examining carefully this frequent variation, that we have to deal here with a Coraco-ulnar head which has lost its girdle attachment and has transferred its origin to the shaft of the humerus, modifying its insertion by joining the remainder of the Biceps muscle.

The relation of this variation to the Brachialis anticus and Coraco-brachialis is obvious and will be referred to below.

In the above series I have encountered this third internal head in the following instances :

1. ♂, England, aet. 73. January 11, 1894.

Left upper extremity.

Internal bicipital head derived directly from the humerus, external to and about 5 cm. above the Coraco-brachialis insertion, between it and the Brachialis anticus, completely free from the latter muscle.

The musculo-cutaneous nerve, after piercing the Coraco-brachialis, passes between the additional head and the main portion of the Biceps muscle.

2. ♂, Ireland, aet. 46. January 11, 1894.

Third internal bicipital head arising from the outer margin of the Coraco-brachialis insertion, and in close connection with the superior and internal origin of the Brachialis anticus.

3. ♂, Ireland, aet. 37. October 17, 1893.

Right upper extremity.

Third bicipital head arising from inner surface of shaft of humerus at the Coraco-brachialis insertion. Separated from the main Biceps muscle by the large muscular branches of the musculo-cutaneous nerve, which perforates the Coraco-brachialis.

The internal head has further been noted in the following cases :

4. ♂, Ireland, aet. 46. January 24, 1894.

Right upper extremity.

5. ♂, Ireland, aet. 62. November 28, 1893.

Right upper extremity.

6. ♂, Germany, aet. 28. October 5, 1893.

Left upper extremity.

Additional head, derived in this instance from the insertion of the Coraco-brachialis, goes mainly into the semilunar fascia.

7. ♀, Germany, aet. 84. November 9, 1893.

Left upper extremity.

8. ♀, U. S., white, aet. 68. November 22, 1893.

Right upper extremity.

Small third internal head, derived chiefly from the tendon of of the Coraco-brachialis, with which it is continuous.

9. ♂, Germany, aet. 60. December 14, 1893.

Right upper extremity.

10. ♂, Bohemia, aet. 30. December 19, 1893.

Left upper extremity.

11. ♂, Italy, aet. 40. December 14, 1893.

Right upper extremity.

II. Relation of Biceps to the adjoining deep ventro-appendicular fibres of the Coraco-brachialis, and, III. to the deep intrinsic flexor of forearm, Brachialis anticus.

The consideration of the variations, described above as the Humero-ulnar internal head and the Coraco-epitrochlear slips, indicate the intimate relation existing between the Biceps and the Brachialis anticus and Coraco-brachialis.

Humphry,* in describing the muscles of the Cryptobranch, accentuates the close relation of the Coraco-brachialis longus and Biceps of this animal. He finds that the former muscle divides into two portions, one of which is inserted into the ulnar edge of the humerus; the other, being nearly as large, is partly inserted into the side of the long tendon of the Biceps, while a bundle of its fibres continues over the elbow and is inserted into the ulna near the joint. Humphry regards this latter portion as the representative of the short or coracoid bicipital origin in man.

We find in this instance on the one hand the direct union of the Coraco-brachialis with the Biceps, and on the other insertion of part of the muscle into the ulna.

Again the Brachialis anticus is in some forms (Pteropus) found to be in direct continuity with the Coraco-humeral,† and in the Scinc the Biceps derives two factors from the humerus, which occupy the position of the Brachialis anticus and are so named by Rüdinger. Humphry sums the mutual relations of these three muscles up as follows:

"They show the Biceps to be an intermediate between the Coraco-humerals and Brachialis anticus, continuous with either or both, and uniting them into one group, extending from the coracoid, along the ulnar and palmar surface of the humerus, to the radius and ulna."

I believe that we may properly regard the variations of the Biceps above referred to in this light. Both the Coraco-epitrochlear slips and the Internal humeral heads speak for the original unity of a muscular plane extending between coracoid and ulna.

The separation of the radius as the rotatory element of the forearm and hand, and the assignment of the corresponding muscular function to the Biceps, have caused the elimination of the ulnar segment of the muscle, leaving the Brachialis anticus as the deep intrinsic flexor connected with the ulna, and reduc-

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* Op. cit., p. 33.

† Humphry, op. cit., p. 164.

ing the Coraco-brachialis to a deep ventro-appendicular muscle confined in its insertion to the humerus.

It is only in the Third Internal humeral head of the Biceps, and in the Coraco-epitrochlear slips, that we still find the evidence of the original connection between these muscles, and see the reversion of the Biceps toward its lost ulnar segment.

It is only necessary to refer in this connection to the interesting account of the structure of the Coraco-brachialis given by Prof. Wood,* and to point out the significance of the occasional Coraco-brachialis longus.

Analysis of cases of Quadriceps flexor cubiti and evidences of the ulnar tendency of the Biceps in variations of the insertion.

In the above series five examples of a four-headed muscle have been encountered.

1. ♂, Ireland, aet. 45. January 9, 1894.

Plate XL. Right upper extremity.

A third additional head (gleno-ulnar) arises by a flat tendon from the capsule of the shoulder-joint, between the long and coracoid heads. It is separated above from the main muscle by the muscuto-cutaneous nerve, after the latter has perforated the Coraco-brachialis. A fourth additional head (coraco-ulnar) arises from the inner surface of the shaft of the humerus, almost directly continuous with the Coraco-brachialis at its insertion, and separated from the Brachialis anticus by a branch to the latter muscle from the musculo-cutaneous nerve.

The left upper extremity of the same subject presents the additional internal humeral head from the Coraco-brachial insertion.

The case affords an example of the typical composition of the four-headed muscle. The gleno-ulnar head passes to the deep and ulnar surface of the main muscle, which is joined lower down by the coraco-ulnar, the continuity of the latter with the Coraco-brachialis being well marked. The superficial part of the muscle is constituted by the large gleno- and coraco-radial heads.

2. ♀, Ireland, aet 40. October 25, 1894.

Plate XLI. Both upper extremities present the same arrangement.

A third anomalous head arises from the glenoid margin and capsule of the shoulder, passes down over the bicipital groove, covering the tendon of the long head, supplied by a branch from the musculo-cutaneous nerve, after the same has perforated the Coraco-brachialis. A fourth additional head arises from the humerus, along the outer margin of the tendinous Coraco-brachialis insertion.

The main portion of the musculo-cutaneous nerve, after per-

*Journal of Anatomy and Physiology, Vol. I., p. 44, 1867.

forating the Coraco-brachialis, passes first between the 3d and 4th additional heads, and subsequently turns down to lie between the accessory heads, a short distance above their junction with the tendon of insertion, and the Brachialis anticus.

The semilunar fascia is well developed, scattered fibres extending up over the brachial artery as high as the internal epicondyle.

This case only differs from the preceding one in the separation of the fourth accessory head from the Coraco-brachialis.

3. ♂, Germany, aet. 62. November 29, 1894.

Plate XLII. Right upper extremity.

A combination of an additional gleno-ulnar head with intermediate pectoral tendon attachment, and a fourth internal humeral head, arising between the Coraco-brachialis and Brachialis anticus.

The insertion is peculiar. The radial tendon is formed by the long head (gleno-radial) and by the deep portion of the coracoid and additional internal humeral heads (coraco-radial). The remaining superficial portion of the regular coracoid and of the internal humeral head (coraco-ulnar) is joined by the entire additional glenoid muscle (gleno-ulnar) and passes superficially inward into a strong tendinous semilunar fascia which is well separated from the radial tendon.

4. ♂, U. S. white, aet. 63. November 7, 1894.

Plate XLIII. Right upper extremity.

The gleno-radial and gleno-ulnar heads are well defined at their origin, fusing before meeting the coracoid segment. The 4th head is derived from the outer margin of the regular coracoid head (coraco-radial?), 5 cm. below level of lesser tuberosity, as a slender slip, about 10 cm. long, which joins the inner margin of the glenoid portion, before the latter fuses with the main coracoid muscle.

5. ♀, U. S. white, aet. 26. November 28, 1894.

Plate XLIV. Left upper extremity.

A third internal humeral head arises from the shaft of the humerus at the Coraco-brachialis insertion and joins the regular coracoid head along its ulnar margin, 2.5 cm. above the level of the elbow. (Coraco-radial and Coraco-ulnar).

The fourth head (gleno-ulnar) is derived from the long tendon, along its outer margin, under cover of the Pectoralis, by a tendon which becomes muscular at the lower border of the pectoral tendon and fuses about the middle of the arm with the external and anterior part of the Brachialis anticus.

Macalister * has found a similar slip once.

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* Op. cit., p. 83.

The variation is interesting as affording an instance of continuity of the Biceps with the Brachialis anticus, and hence of a direct ulnar destination of some of the bicipital glenoid fibres.

Variations of insertion pointing to ulnar attachment of Biceps.

1. ♂, Assyria, aet. 28. November 15, 1894.

Plate XLV. Right upper extremity.

A muscular belly, entirely separate from Brachialis anticus, arises from the lower part of the inner margin of the humeral shaft, and passes downwards and outwards, underneath the Biceps, dividing into two portions. The internal division passes to reinforce the semilunar fascia; the external stronger bundle dips into the cubital fossa to the inner side of the radial Biceps tendon, joining it, and giving some fibres to the fascia of the Supinator brevis. The additional muscle in this instance is evidently a compound of portions of both Coraco-radial and Coraco-ulnar, whose origin has shifted downwards to the humeral shaft, the proximal portion remaining as the coracoid head of the regular Biceps and the Coraco-brachialis.

The compound character of both the external radial tendon of the Biceps and of the semilunar fascia (internal or ulnar tendon) is well shown by this case.

2. ♂, Ireland, aet. 57. October 7, 1893.

Right upper.

Tendon slip from radial biceps insertion into lesser head of Pronator teres.

3. ♂, Germany, aet. 58. January 23, 1894.

Right upper.

Tendon slip from radial Biceps tendon into Pronator teres and deep fascia of forearm.

Macalister * describes insertions of the Biceps into the coronoid process, Pronator teres, Coronoid insertion of Brachialis anticus, capsule of elbow and the origin of some of the flexor muscles.

While completing this paper a number of additional bicipital variations, bearing out the views expressed relative to the composition of the muscle, have come under observation. Among them the two following instances illustrate some of the important morphological features of the muscle so well that they are added to this paper.

1. ♂, Ireland, aet. 67. January 22, 1895.

Plate XLVI. Left upper extremity.

I. Glenoid Heads.

The outer bicipital head (Gleno-radial) is well developed. In its upper portion the tendon is overlapped by a distinct band,

* Op. cit., p. 83.

arising from the capsule of the shoulder joint and attached to the deep surface of the Pectoralis major tendon (Capsulo-pectoral variety of Gleno-ulnar head). About 4 cm. above the elbow joint a slip separates from the inner border and deep surface of the main muscle, and, becoming tendinous, passes downward and inward to the anterior border of the ulna, just below the coracoid insertion of the Brachialis anticus. (Persistent distal portion of Gleno-ulnar division).

II. Coracoid Heads.

A broad muscle, arising with the Coraco-brachialis from the coracoid process, divides at the level of the lower Pectoralis margin into : (a) The usual short or coracoid head, which passes down and out and joins the outer head a little above the middle of the arm (*Coraco-radial division*). (b). An internal muscle, completely free from Coraco-brachialis, which immediately subdivides into two equal portions. Of these the posterior and internal muscle descends vertically over the Coraco-brachialis insertion, and terminates at the junction of middle and lower one-third of the arm in a strong tendon, which passes down, at first free and subsequently fused with Struther's ligament, to the internal epicondyle. (*Coraco-epitrochlear variety of Gleno-ulnar head.*

The anterior muscle, lying upon the Brachialis anticus and the internal intermuscular septum, remains completely free from surrounding structures and terminates in a strong tendon which passes over the elbow joint and is inserted into the coronoid process of the ulna, just internal to the Brachialis anticus insertion. (*Typical Coraco-ulnar head of muscle.*)

This case is especially important, as it presents not only the more common proximal vestiges of the obsolete ulnar divisions, but also exhibits perfectly the rare distal or insertion portions, in their complete form, attached to the ulna.

The separation of the Biceps insertion from the ulna and the assignment of the muscle, as a supinator, to the radius, would lead us to expect this disproportion, as regards frequency of occurrence, between reversions of the complete distal and proximal segments of the lost ulnar division. The distal or insertion portion of the ulnar division was the first to disappear at the insertion into the ulna, and consequently reverts in a very much smaller percentage in its complete form than the proximal or origin portion, whose existence has, so to speak, been prolonged by the opportunity of uniting with the radial division.

The above instance exhibits these features of the muscle-plan perfectly, and the preparation has been added to the Variation-series of the Morphological Museum of Columbia College.

2. The second case, recently observed, which presents points of especial interest in connection with the subject of this paper, exhibits one of the important relations between Biceps and Brachialis anticus, and emphasizes the significance of the semilunar fascia, as representing the remains of an ulnar bicipital division which has lost its skeletal attachment, in accordance with the functional specialization of the muscle as the main supinator of the limb.

♀, Ireland, aet. 54. March 15, 1895.

Plate XLVII. Right upper extremity:

This case affords a well-marked example of the original connection between Biceps and Brachialis anticus.

The origin of the Biceps in this arm is normal, as is the arrangement of Coraco-brachialis. A strong muscular bundle separates from Brachialis anticus a short distance below the Coraco brachial insertion. The outer and larger portion of this muscle joins the deep surface of the Biceps and passes with it to the radial insertion. The inner part continues downward and inward, gives off a narrow tendon which passes with the remainder of Brachialis anticus to the coronoid process, and then expands into the semilunar fascia, which is well developed, crossing obliquely over the brachial artery.

The additional muscle in this instance is evidently an Internal Brachio-ulnar muscle, which, however, presents not only the usual connection with the radius by means of the bicipital junction, but preserves its original ulnar insertion both by the tendon slip to the coronoid process and by the development of the entire semilunar fascia. The significence of the latter structure, entitling it to be considered as the distal portion of an ulnar bicipital segment which has lost its skeletal attachment, is strongly emphasized by the arrangement of the aberrant muscle in this subject.

Stated Meeting.

May 20th, 1895.

The Academy met with Vice-President Stevenson in the chair; ten persons present. The minutes of the last meeting were read and approved. The Secretary presented the nomination of Mr. Edward Gould, Dobbs Ferry, for resident membership, and it was referred to the Council. The Secretary read by title the following paper, which was referred to the Publication Committee.

T. L. Casey, Coleopterological Notes VI.

Prof. D. S. Martin read the following note from Mr. George F. Kunz, on Phosphorescent Diamonds:

The luminous properties of gems have been referred to from the earliest times. The phosphorescence of the diamond was treated at some length by Robert Boyle in 1666 and by Du Fay in 1751. Only certain diamonds emit light or phosphoresce on exposure for a time to the rays of the sun, or of electric, calcium or other intense light. The various colors of the diamond are evidently due to the presence of hydrocarbons, similar to those which are artificially made in such endless variety and of all known colors, and which often fluoresce and phosphoresce. After a personal examination of a great number of diamonds, it appears that only certain ones fluoresce on exposure to the ultraviolet rays of an electric or other strong light, and from the observations made it is very evident that this fluorescence and phosphorescence is a property only of those diamonds that contain a certain bluish-white substance, and it is this substance that fluoresces and phosphoresces and not the diamond. This is, undoubtedly, a hydrocarbon, for, as stated above, this property of fluorescence and phosphorescence is marked in many hydrocarbons, notably anthracine. I therefore think it would not be inappropriate to give this substance a definite name, and I propose that of Tiffanyite. GEORGE F. KUNZ.

The following memorial was then presented in accordance with the resolution of April 22, 1895:

The New York Academy of Sciences has learned with profound sorrow of the death of Professor James Dwight Dana, of Yale University. For over fifty years Professor Dana has been one of the central figures in American Science, and his loss leaves a gap that will not soon be filled. Born in 1813, his inclinations were early manifested for those branches of science to which he afterwards devoted his life, and in his early manhood he began the researches in Geology and Mineralogy that afterwards bore such rich fruit. Geology, and to an even greater degree Mineralogy, were subjects that then especially commanded the attention of the Lyceum of Natural History, as this Academy was formerly called. The Lyceum early recognized the promise of Professor Dana, and made him a Corresponding Member in 1836, when he was but twenty-three years of age. His third published paper, entitled "A New Mineralogical Nomenclature," was read before this Society in May, 1836, and was printed in the Annals of that year. Six years later he was elected an Honorary Member in recognition of his System of Mineralogy (1838) and of his four years of labor on the Wilkes Exploring Expedition (1838–42). He became one of the editors of the American Journal of Science in 1846, and for nearly fifty years retained this position. To him in no small degree is to be credited the magazine's characteristic attitude of just and well-balanced criticism of current work and publications. Our knowledge of the Zoöphytes and Crustaceans was vastly increased by the published results of his voyages, and his contributions to the geology of volcanoes and coral islands were no less important. In 1862 his Manual of Geology appeared and became at once the standard American text-book. It is a source of gratification that he lived to complete its revision, and that the last edition, in vastly improved and augmented form, was brought out by its original author.

Of serene and cheerful disposition, Professor Dana aspired to high spiritual as well as intellectual attainments; his personal influence was uniformly thrown on the side of exalted ideals. As teacher and friend he will be mourned by many hundreds of his students.

Be it therefore

Resolved, That in the death of Professor James Dwight Dana, American Science has lost one of its most eminent and successful investigators, education a great teacher, and the world a true and just man.

Resolved, That this memorial be spread upon the minutes of the Academy and be printed in the Transactions.

D. S. MARTIN,
J. J. STEVENSON,
J. F. KEMP,
Committee.

Prof. Martin called the attention of the Academy to a reception to be tendered to Prof. Thomas Egleston, by the Mineralogical Section of the Brooklyn Institute, May 21st, and invited the members of the Academy to be present. The Geological Section then organized and listened to the following papers, no one of which was intended for publication.

J. F. KEMP. The Iron-ore Bodies at Mineville, Essex Co., N. Y., illustrated by mine maps and sections on glass, and by the lantern.

G. VAN INGEN. The Significance of the Recent Studies of Mr. G. F. Matthew, on Cambrian Faunas.

The Academy then adjourned.

J. F. KEMP,
Recording Secretary.

TWO NEW CAMBRIAN GRAPTOLITES WITH NOTES ON OTHER SPECIES OF GRAPTOLITIDÆ OF THAT AGE.

BY G. F. MATTHEW.

(Read by title, April 8th, 1895.)

In a collection of shale containing *Dictyonema flabelliforme* made by Mr. G. van Ingen, for Columbia College, New York, last summer, were two new graptolites which he left with me for examination. These were studied in connection with collections from the same locality made for me by Messrs. W. D. Matthew and Geoffrey Stead, and some additional points of interest noted in reference to other species.

It is not many years since we were accustomed to look upon the Quebec Group as containing the first true graptolites, meaning thereby the Rhabdopora, but the discoveries of the last ten or fifteen years make it necessary to modify this conclusion. Not to mention the species represented by obscure or imperfectly preserved remains of the Lower Cambrian (Olenellus and Paradoxides Zones), there is obviously at a higher horizon in the Cambrian System a fair representation of the Rhabdopora, though not the wealth of forms which meet us at the threshold of the Ordovician System.

The graptolites of the Upper Cambrian centre around the form known as *Dictyonema flabelliforme* Eichwald (=*D. socialis* Salter), which in its earlier stages was actually a twig-graptolite and only in its later stages acquired the reticulate habit. This widely spread and well known species is of value as marking a definite stage, *in* the Cambrian as understood by English Geologists, but *at the summit* of this System as limited by those of the continent (Europe).

Still though the horizon of *Dictyonema flabelliforme* is well known, the extent to which these Cambrian Rhabdopores are associated with it does not seem to have been clearly ascertained in Europe, for by some authors they are placed a little earlier in time, and by others a little later than the above species. As regards their position in America, however, there is no question, as they occur in intimate association with *Dictyonema flabelliforme*, and that at more than one level. This inclusion in the Dictyonema Zone, apparently different from the conditions of occurrence in Europe, may be due to the fact that the species above named has a considerable vertical range on this side of the Atlantic. In Europe, and especially in Scandinavia, this Dictyonema has its place above the trilobitic fauna associated with *Peltura scarabeoides*, technically known as the Upper Olenus Zone, but in the Canadian Cambrian beds we find this Upper Olenus Fauna extending into the Dictyonema Zone, since the trilobites of this fauna occur in lentiles with layers included in shales which contain this Dictyonema. Our practice, however, has been to regard the beds above the horizon to which these trilobites so far as known are limited, to be the true zone of Dictyonema, and corresponding to the beds so designated in Europe; and to include the beds below, in which Leptoplastus, Sphærophthalmus and Peltura are found, and which also contain Dictyonema, as a lower zone corresponding to the upper part of the Upper Olenus Zone as developed in Wales and Scandinavia. Further remarks upon this subject will be found in a later part of this paper, where the several species of Rhabdopora are described.

All the graptolites of this early horizon that may be included in the Rhabdopora, appear to be of the family Dichograptidæ and are chiefly of the two important sections typified by Bryograptus and Clonograptus, the former with a distinct sicula and the latter devoid of this initial part; or with the sicula obscure, absorbed, or merged in the funacle.

The succession of the Dichograptidæ in the Cambrian and Lower Ordovician is a good exemplification of increased condensation of structure due to selection; for the many branched forms of the former are gradually replaced by the Tetragrapti and these by the Didymograpti of the Upper Arenig. As the branches of these graptolites diverge at a variety of angles in the different species, so a like variation in the attitude of the branches is found in the various species of Bryograptus in the Upper Cambrian rocks. From a form belonging to this genus we may suppose that *Dictyonema flabelliforme* arose, for even when this species was flourishing and dominant, we do not find that the reticulating threads that knit the branches together were present on the primary and secondary branches, and even the tertiary branches are sometimes devoid of them. From this acquired habit of linking its branches together, or by the innate vigour of its constitution this species was enabled to overtop and dwarf its fellows, so that while the other Brytograptids are comparatively of puny size, individuals of this Dictyonema have been found eight inches in length,* and with nearly two hundred branches to the hydrosome.

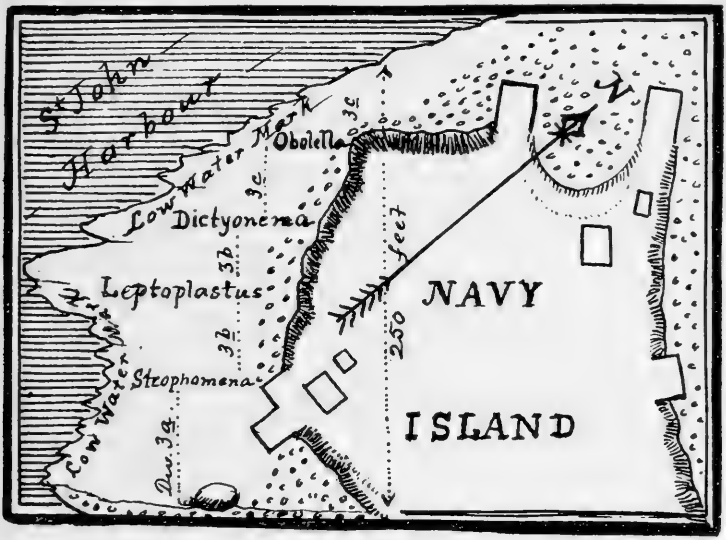
While the genus, from which we may suppose that Dictyonema sprang, had but a short life, Dictyonema was able to maintain itself in competition with the vigorous Dichograpti of of the Quebec Group and thus contribute a very respectable contingent to the Ordovician Fauna; and if the species referred to it from the Silurian (Upper) were truly of this genus it had a wider range than any of the graptolitic genera.

Section at Navy Island.

The shore of this island where the fossils were obtained that form the subject of this communication has on its western side black and dark gray shales of the lower half (or more of Division 3 of the St. John Group, exposed between high and low water mark. These ledges are swept clean by the force of the current of the river which passes here, and so furnish available opportunities for collecting the fossils which they contain, when the tide is low. The three lower zones of Division 3 are ex-

* The Graptolites described by Heisinger, p. 21.

posed on this shore, the higher zones being out of view in the channel of the river. Trilobites and Brachiopods are not now easily obtained, but there is no lack of hydrosomes of Dictyonema to be had, both above and below the horizon where they are marked on the map. The strike of the beds is about N. 40°



E., and the dip 80° to the south, the measures here being overturned. On the east and south sides of the island the slate ledges are concealed by Post-pleiocene deposits.

I have been somewhat explicit in describing this island, as it is the only place in the St. John Basin where *Dictyonema flabelliforme* and its associated graptolites have been found.

CLONOGRAPTUS, Hall, 1843.

CLONOGRAPTUS PROXIMATUS n. sp. Pl. XLVIII. figs. I, *a* to *d*.

Hydrosome subsymmetrical on the two sides of a plane at right angles to the funacle, but asymmetrical on the two sides of a plane parallel to that part. One of these sides, which may be called the patent side, occupies more than a semi-circle; the other, the confert side, spread its branches over about one-third of a circle. Not counting the funacle as a branch, on the patent side the angles between the secondary, tertiary and quaternary branches are respectively approximately 90°, 60°–70° and 40°–50°, but on the confert side 40°–50°, 40° and 30°–40°. On both sides branches are developed to the 5th order (or 6th if the funacle be counted as the primary branch).

The funacle is short. The primary branches also are short (and the secondary as well on the patent side of the hydrosome). The ultimate branches are more numerous on the patent side, because on that side they more frequently reach the fifth order of division.

The branches are slender, but rather rigid and the hydrotheca are widely spaced, there being about 8 in a space of 10 mm., and they are closely appressed to the branches. Apparently the mouth is at right angles to the body of the theca.

Young hydrosomes show first the development of one direct extension of the hydrosome at each end of the funacle and apparently a branch on each side at each end, thus seemingly departing from the dichotomous order. But a closer examination shows that the apparent ternate branching of the funacle is due to the shortness of the branches of the first order, which brings those of the second order, especially on the patent side of the hydrosome, in close approximation to the funacle.

This interesting species is planly a Clonograptus, though it shows points of comparison with other genera. On the patent side of the hydrosome the shortness of the primary and secondary branches recalls that of the typical Dichograpti, but from Dichograptus proper it is clearly distinct by the numerous branches in the distal parts of the hydrosome. In the slender branches and the distant cells it is like *Clonograptus tenellus*, and like the later Azygograptus and its allies. From *C. tenellus* it is clearly distinct by the short funacle and short primary and secondary branches.

Dr. J. C. Moberg has described a graptolite from Hunneburg, Sweden (*Bryograptus (?) sarmentosus*), which by its abbreviated primary and secondary branches resembles ours. It is from the same layers as *Clonograptus tenellus*. Dr. Moberg refers it with doubt to Bryograptus, and mentions that the branching of the large branches is like that of Clonograptus. It can only be thought a relative of our species if the supposed sicula be considered as a primary branch; in which case the mode of branching would be similar.

In 1871 Dr. Linnarsson described a graptolite from the uppermost part of the Olenus Zone, which, like our species, was one of the early types of the genus Clonograptus *Dichograptus tenellus*.* He used for it the generic name Dichograptus, as at

*Om några försteningar från Sveriges och Norges och "Primordialzon" öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, 1871, No. 6, Stockholm.

that time the term Clonograptus had not been generally applied to the group of graptolites which bear it, otherwise we may surmise that Linnarsson would have used it. Linnarsson's examples, as he himself, says were imperfect. His diagnosis is: "Rami tenuissimi, regulariter dichotomi, circiter ½ mm. late. In 10 mm. 7–8 cellulæ angustæ, elongatæ, subrectæ, apertura runcata, transversa." In its slender branches and distant hydrotheca it differs from the type of the genus occurring in the Quebec Group, and is small and slender like the St. John species.

Since Linnarsson first described the species, Dr. J. C. Moberg has added largely to our knowledge of it by describing a number of examples from Hunneberg, found in the collections of the Geological Survey of Sweden.* These are more complete than those described by Linnarsson, and give a better conception of the species and of its generic place. The examples figured by Moberg show the species complete from the sicula to the extremities of the branches, and also show that the species did uot reach the fifth order of branching as did *C. proximatus.*† The most obvious point of difference, however, is the long funacle and primary and secondary branches, through which a more open form is given to Linnarsson's species than to *C. proximatus.*

Size of *C. proximatus.* Diameter of the hydrosome 25 mm., width of the twigs about ½ mm.

Horizon and Locality. In the black, carbonaceous shales of Band *c* of Division 3 of the St. John Group, at Navy Island in St. John Harbor. Scarce. Collected by G. van Ingen.

The close association of this and the species described below with *D. flabelliforme* makes a comparison of the geological horizon of our species with that of *C. tenellus* of interest. Linnarsson has stated distinctly that the latter is found together with *Sphærophthalmus alatus* Bœck, and thus belongs to the highest layers [of the alum slate or Olenus Zone]. This reference is called in question by Dr. Moberg, who gives various reasons for claiminig this graptolite as belonging above the Dictyonema Zone.

Among other things he says that in all the literature heretofore given relative to the geological age of the shale in which *Clonograptus tenellus* Linrs. is contained at Hunneberg, the age given rests upon the statement left by Linnarsson, who first distinguished that layer. This statement I have given above, and

* Om skiffern med *Clonograptus tenellus* Linrs. dess fauna och geologiska ålder. Geol. Fören ; Stockholm Förhandl Bd. 14 Häft 2, 1892.

† Moberg's description speaks of the fifth order, but this is because he counts the funicle as the first branch. As we have found no theca on the funicle of *C. proximatus*, we do not regard it as a branch, but continue Hall's use of the term funacle.

it is the basis of the references of this fossil by Lapworth, Brögger and Hermann to the Olenus beds, or to the highest part of the same, and thus older than the Dictyonema beds. Moberg explains that when Linnarsson referred *C. tenellus* to the uppermost part of the Olenus Zone he had not yet set off the Dictyonema bed from that zone, and that the species cannot now any longer be considered as belonging to that zone. He sums up his argument with the following conclusions:

(1) No piece of shale with *C. tenellus* contains any *Sphærophthalmus.*

(2) *Sphærophthalmus* notwithstanding occurs even here in a layer, which immediately borders on the Dictyograptus shale.

(3) At no place except at Hunneberg as any *C. tenellus* been found in the uppermost part of the Olenus Beds, and this bed is only known from a loose piece.

(4) On the contrary graptolites of the type of *C. tenellus* and those occurring with it, have been found in most places in the layer which lies closest above the Dictyograptus Beds.

(5) *Dictyograptus flabelleformis* shale—when new representatives of the genera *Clonograptus* and *Bryograptus* occur, both close above and close beneath (namely at Hunneberg), but not together with the above named species—by its appearance affords an intelligible explanation of the gap in the continuous development of the other graptolitic genera.

Moberg, however, appears to think that there is some mistake in regarding *C. tenellus* as in any case older than the Dictyonema Zone, for he interested Herr G. von Schmalensee to collect material for him bearing on this question, and quotes his account of the geological position of the species at Hunneberg, namely, that the shales there which contain *C. tenellus plainly overlie the Dictyograptus shale, and only come in contact with the Olenus shale in places where the Dictyograptus shale has been wedged out.*

If we depend upon these researches of Herrn Moberg and von Schmalensee, the little graptolite found by Linnarsson belongs properly above the Dictyonema beds. It will therefore be of interest to geologists to know that the genus as represented in *Clonograptus proximatus* existed at St. John with Dictyonema.

BRYOGRAPTUS, Lapworth.

Bryograptus patens, Matt. Pl. XLVIII., figs, 4 *a* to *c*.

Nat. Hist. Soc. N. B. Bull. x., p. xi.

Trans. Roy. Soc. Can., vol. x., sec. iv., p. 17, pl. vii., figs. 1 *a–d*.

Primary branches of the hydrosome spreading, at first dichotomous [at short intervals], then more irregularly branching [in a dichotomous manner]. There are about 10 hydrothecæ in the space of a centimetre, and the branches [of the hydrosome] are about one-half of a millimetre wide [or more]. The cells of the hydrosome are directed forward [and upward], and each terminates in a mucronate point. The primary branches do not appear to be celluliferous, but cell-bearing branches shoot out from the primary.*

Size. Width of the hydrosome 15 to 20 millimetres; height, about 10 millimetres.

Horizon and locality. Black shales of Div. 3*b* of the St. John group at Navy Island, St. John Harbor. Found last summer also in the shales of Div. 3*c* in occasional layers, over which the hydrosomes of this species are freely scattered.

There is a considerable variation in the attitude of the branches of this species. The figures in Trans. Roy. Soc. Can. are of the spreading variety from Div. 3*b*. The one here given is the average form of those in Div. 3*c*, though some with even more erect branches are to be found.

Dr. J. C. Moberg figures a species from Hunneberg in Sweden (*B.* (?) *Hunnebergensis*), whose branches have the attitude of those of *B. patens*, but it is a much smaller species and less frequently branched.

A species from the Shineton shales, *B. Callavei*, described by Prof. Lapworth, bears a close resemblance to this species in the attitude of its branches, but the figure given represents it as bifurcating regularly, and presumably in one plane, as there are but two main branches; thus it has not the shrubby growth of *B. patens*, but in its simple branching resembles *B* (?) *Hunnebergensis* of J. C. Moberg. *B. Callavei* does not agree with our species in the spacing of the thecæ on the hydrosome; it has $7\frac{1}{2}$ cells to the centimetre, while *B. patens* has about 10 cells. It would appear from this that there is no described species to which *B. patens* can be referred.

Bryograptus spinosus, Matt. Pl. XLVIII., figs. 3 *a* and *b*.

Clonograptus spinosus. Trans. Roy. Soc. Can., vol. x., sec. iv. p. 97, pl. figs. 3 *a* and *b*.

A slender species with distant hydrothecæ set very obliquely to the axis, and having a spine at the outer end of each hydrotheca. The branches of the hydrosome are about three-quarters of a millimetre wide, and there are about 8 hydrothecæ in the space of 10 millimetres.

*The bracketed parts of this paragraph are not in the original description of the species.

This species is easily distinguished from *Dictyonema flabelliforme*, with which it is found, by its larger and more distant hydrothecæ [also by the thinner substance of its hydrosome]. This species, of which only fragments were had at first, was doubtfully referred to *Clonograptus*; the better material now had shows that it cannot be thus placed, as the mode of branching is that of Bryograptus. The branches are ascending, clustered, and extend to the sixth degree of division.

Size. Length of the hydrosome 35 + mm.; width, 30 + mm.

Horizon and locality. First described from Div. 3*b*, now also found in Div. 3*c* at Navy Island.

This species is nearly related to *B. Kjerulfi* of the Norwegian Cambrian rocks, and has about the same number of thecæ on a similar space of the hydrosome. *B. Kjerulfi* has 7–9 according to Lapworth, but Brögger's figure gives 10 cells in a distance of 10 mm. Lapworth's figure shows a branching to the third degree, Brögger's to the fourth, but the branching in *B. spinosus* extends to the sixth and seventh degrees; it is much more bushy.

BRYOGRAPTUS LENTUS n. sp. Pl. XLVIII. Figs. 2 *a* and *b*.

The initial part of the hydrosome is wanting. Branches ascending, slender, crowded, flexuous; angle of furcation narrow (30° to 40°), except at the final angle where it is about 40° to 50°. Hydrothecæ numerous, continuous on all the branches known, free for most of their length, somewhat spinous-pointed, about 7 or 8 in the space of ten millimetres. Extreme width of the branches about 1 mm.

The width of the branches of this species is greater than that of the other Rhabdopores that occur with it, but the thickness of its branches is not as great as that of the branches of *Dictyonema flabelliforme* and its thinner substance serves to distinguish it from that species. It may be known from *Bryograptus spinosus* by its somewhat broader branches and its larger thecæ.

A group of eight branches of an individual of this species is known, and from the fact that the cells on these branches are all turned in one direction it seems probable that the initial branches were far enough off to indicate a hydrosome of considerable size, of which this was a portion of one-half.

Size. Hydrosome 40 or more mm. across, and about 50 + mm. long.

Horizon and locality. In the black shales of Div. 3*c* with *Clonograptus proximatus*, at Navy Island. Scarce. This type collected by G. van Ingen.

Although we have not the initial part of the hydrosome of this species, it is referred to Bryograptus on account of the general arrangement of the branches; by comparing it with *B. spinosus* the arrangement of the branches is seen to correspond to that of half of those of a hydrosome of that species; it however is a larger species and has larger thecæ.

Bryograptus (?) retroflexus (?) Brögger.

Die Silurischen Etagen 2 und 3, p. 37. Pl. xii., fig. 22.

Still another species of graptolite appears to be indicated by some fragments which are not branched, and appear to belong to a species with long branches such as the above. No sicula or primary branches have been recovered, and so the generic reference is doubtful. There are about 10 thecæ in the space of 10 millimetres.

Horizon and locality. Black shales of Div. 3*b*, at Navy Island, St. John Harbor, with Dictyonema. Scarce.

A feature in Bryograptus which we see prevalent also in later related types is the orientation of the cells on the branches on each side of the hydrosome toward the central line of the latter. Occasionally a branch from one side of the hydrosome will start off at a wide angle toward the other side; in this case the rule for the branches of this side is reversed, and the cells face toward the remainder of the branches of the side from which it sprang. This is obviously due to the attitude of such a branch diverging at a wide angle from the direction of its fellows; this divergence made it necessary that the position of its thecæ should be reversed, in order that the mouths of the cells might be turned upward.

CALLOGRAPTUS, Hall. Pl. XLVIII. fig. 5.

A few obscure examples of a dendroid graptolite were obtained, which appear to be of Hall's genus above named; the branching is not very well shown, but the lower branches appear to have been rather thick, and light cross-bars appear at intervals higher up, as though the branches were in some degree connected by transverse threads after the manner of Dictyonema. No cells were seen.

Size. Length of the hydrosome about 12 mm. Width about 10 mm.

Horizon and locality. The Dictyonema beds (Div 3*e*) at Navy Island. Scarce.

DICTYONEMA FLABELLIFORME Eichwald. Pl. XLIX. figs. 1 and 2

Note on this species and its associated fauna.

In the material collected last summer a good many examples of a vasiform variety occur, which might pass for var. *confertum* Linrs., but that the hydrothecæ are closely set as in var *Acadicum;* there are 15 or 17 thecæ in the space of 10 millimetres.

The hydrothecæ of Dictyonema are about twice as numerous in the same space on the branches, as those of most species of Bryograptus; they are arranged in a double row, alternating; if we suppose two branches of a Bryograptus joined at the side with the cells alternating, a branch similar to that of a Dictyonema would be produced; owing to its double row of cells Dictyonema produces a thicker branch than Bryograptus.

In one or two examples of this species collected by Mr. G. van Ingen, there appears to be short rootlets developed from the proximal end of the sicula (See Pl. XLIX., figs. 1 and 2). These were adult examples, from the horizon 3*c*, where this species is most abundant. It might appear from such examples as these, that it would be possible to show the existence of a sedentary variety or stage in this species; still, it does not seem that this condition of the hydrosome is at all frequent, for among scores that have been examined since these were found, none with roots have been detected. Possibly these processes may have had some other office than that of anchoring the hydrosome to the bottom; so far as they are visible they are too short to afford more than a very feeble foothold at the surface of the soft ooze in which Dictyonema was buried.

Although we can recognize three different types of Rhabdopores in the Dictyonema beds (including 3*b* and *c*), their occurrence is comparatively rare. I suppose with an hundred layers bearing in profusion the skeletons of Dictyonema, one would occur loaded only with the remains of Rhabdopores, though others will be found in which such remains are mixed with and masked by the skeletal parts of Dictyonema. Usually the former are confusedly crowded together on the layers where they they alone occur, and only at rare intervals does a straggler from the crowd appear on the surface of a layer with its parts so displayed that the plan of structure can be made out.

So far as numbers are concerned the genus Bryograptus bears off the palm among these Rhabdopores, for it exhibits the greatest profusion of individuals, but occasionally a mass of the little *Clonograptus proximatus* is found covering the surface of a layer. The remains of *B. lentus* are scarce, and those of *B.*

spinosus are not usually aggregated in such considerable masses on the layers as either *B. patens* or *Clonograptus proximatus*.

Considering the considerable thickness of beds of black shale without admixture of other sediments through which, in the St. John Group, Dictyonema is distributed, it would appear that conditions favorable to the existence of this species continued in the Acadian region for a long time. This species was not here as in some parts of Europe a solitary Graptolite, but had these small Rhabdopores associated sparingly with it, so far as we have traced it, in all the measures in which it has been found, hence we may consider them a part of the Dictyonema Fauna.

Furthermore it appears that the presence of this graptolite fauna was not incompatible with the presence of trilobites. Angelin, years ago, claimed that he had found a trilobite, *Acerocorne ecorne*, in the Dictyonema beds, but later palæontologists have thought that this could not have been the case, and have suggested that this species was really from layers with *Sphærophthalmus alatus* below the true Dictyonema beds,* as will be seen by reference to the introductory part of this paper; both may be right if there was a commingling of the Dictyonema and the Peltura faunas in Sweden such as occurred in the St. John Basin. To sustain such a view however, a wider range would need to be given to the Dictyonema fauna in northern Europe than has been popularly assigned to it.

Among other organisms that have been assigned to the Dictyonema beds of Sweden, we notice an Obolella, *O. Salteri*, Hall.† Examples of this genus and of Acrotheta have also been found in grey layers enclosed in the Dictyonema shales of St. John. Two other Brachiopods are characteristic of the Dictyonema shales in their normal condition (*i. e.* black bituminous shales) viz.: *Obolus refulgens* and *Lingulella Nicholsoni* (?) so that this graptolite (*Dictyonema flabelliforme*) had companions that were members of other classes of the Animal Kingdom.

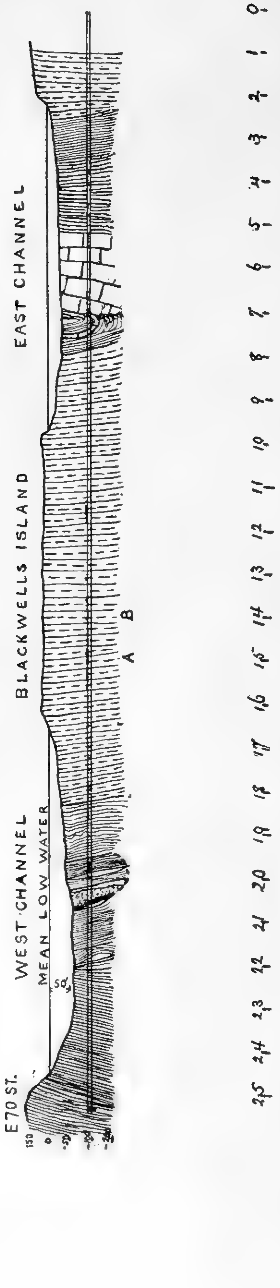
THE GEOLOGICAL SECTION OF THE EAST RIVER, AT SEVENTIETH STREET, NEW YORK.

By J. F. Kemp.

The completion of the new tunnel for the East River Gas Company from the foot of East 70th street, underneath Blackwell's Island to Ravenswood, has brought to light a number of

* Angelin seems to intimate that it was above rather than below the Dictyonema bed.

† Om skifern med Clonograptus tenellus. J. C. Moberg, p. 100.



interesting facts regarding local geology. By the courtesy of Mr. Charles M. Jacobs, the chief engineer of the work, the writer has had the opportunity to visit the tunnel and collect a series of specimens. The profile of the tunnel published with Mr. Jacobs' report to the East River Gas Company has furnished the outline of the figure here given, which, so far as the reduced scale admitted, is in true proportions. The tunnel is 2516.4 feet from shaft center to shaft center, and about 10 feet 6 inches in diameter. Its roof is about 106 feet below mean low water. The difficulties in the way of soft ground and the influx of river water, which were overcome, make the enterprise an exceptionally creditable one to those in charge. The worst of these were met under the west channel of the East River and were caused by weak and rotten seams of rock, and one old crack filled with river mud and sand, that at one time opened up the tunnel to visits from live crabs. In its engineering relations the tunnel is of special interest because the softest ground was penetrated with the air pressure at 48 pounds, which is the highest yet used in work of this character. It necessitated only $1\frac{1}{2}$ hours working shifts with an hour between each of rest outside the lock, and only $4\frac{1}{2}$ hours working time for each man daily. The accompanying section illustrates the geology. Beginning on the New York side the rock is a thinly laminated mica schist, much contorted, but with a well marked general dip of about 80° west. A few small pegmatite stringers are met. Under the microscope the rock is seen to consist of biotite, in parallel scales, of quartz, orthoclase, plagioclase, magnetite and a few little zircons. This rock continued for 321 feet from the west shaft, except that it was at times a little harder or softer, and had an occasional seam that was wet. At this distance the following section was met.

9 ft. soft kaolinized pegmatite, of the consistency of cheese, but with vertical lines of garnets and biotite.
3 in. quartz vein.
6 ft. kaolinized pegmatite.
8 ft. soft green chlorite schist, *i. e.*, decomposed mica schist.
6 ft. green chlorite scales, with quartz nodules.

Total, 29 ft. 3 in.

The next 80 feet were firmer but were still of much decomposed and chloritic mica schist. The following 98 feet were as follows:

7 ft. white kaolinized pegmatite.
5 ft. soft black mud with lumps of lignite, which with the next seven feet evidently filled a fissure.
2 ft. coarse river sand with abundant pyrites.
5 ft. sand and black mud with lignite and balls of pyrites.
22 ft. white kaolinized pegmatite with lumps of fœtid quartz.
4 ft. do, streaked with chlorite.
11 ft. kaolinized pegmatite.
42 ft. soft green chlorite schist.

Total, 98 ft.

Samples of this white clay and green chlorite were sent to me when first penetrated because their close superficial resemblance to the Cretaceous Amboy fire clays and overlying green sands gave rise to the suspicion that a remnant of the Cretaceous had remained in the bottom of the East River, but a moment's close examination showed the fallacy of the supposition. It was in this section that the chief difficulties in tunneling were met. The firmer rock to the east came in at an angle of 45°, and after some rather unsound schist passed into the solid rock of Blackwell's Island, This is a gray gneiss much like that at the north end of Seventh avenue and near 150th street. At one place 150 to 250 feet east of the west shore line of the island it proved to be under great strain, so that from time to time, even six months after the tunnel was opened, it cracked with reports like a pistol shot, and at intervals masses fell from the roof. It was also a very hard rock to drill. At 260 feet from the east shore of Blackwell's Island a soft seam was met, and a little farther 10–12 feet of dolomite. Beyond the dolomite 50 feet of soft decomposed mica schist were cut, forming the shattered trough of a syncline on whose eastern side were 160 feet of white crystalline dolomite, precisely like the outcrop at Kingsbridge. The eastern limit of this is charged with phlogopite. It was succeeded by mica schist at first moderately solid. In thin section it is found to be thickly charged with pyrites, and to the decay and oxidation of this element of weakness is doubtless due much of the decomposition that marks so many bands of the schist. The mica schist soon gave way to another soft seam, 30 feet across, and like those on the New York side consisting of kaolinized pegmatite and greasy scales of chlorite—with lumps of quartz. Several minor alternations of rotten and solid seams intervened before firm schist was again encountered. On the Ravenswood shore a massive hornblende gneiss or granite was met entirely different from any of the other rocks. In thin section it shows brown hornblende, quartz, orthoclase and plagioclase.

The most interesting feature of this cross-section is the discovery of crystalline dolomite so far down the river. We have known of its presence under the Harlem river for many years; in fact, ever since Professor Dana foretold its probable discovery and the tunnel of the new aqueduct above High Bridge demonstrated it. The belt in the east channel opposite Ravenswood is, however, the prolongation of a belt that appears east of Mott Haven, unless faulting has thrown it to the east. It is also important to note the close association of decayed pegmatite and chlorite with the limestone of the east channel, for it and similar associations elsewhere give us ground for believing that the kaolinized soft seams in the west channel indicate the former presence of limestone there. Dr. F. J. H. Merrill at once pointed this fact out when looking over the writer's specimens and notes. If so it must have been a shallow trough now worn completely away, but its presence would simplify the problem of the development of our local drainage lines on the east side of Manhattan Island; they would then be uniformly due to the relatively easy erosion of limestone. There is thus some ground for thinking each river channel a compressed syncline, but from one isolated section like this it would hardly be justifiable to draw too lengthy conclusions about local stratigraphy. There is good reason to think the Ravenswood rock an intrusive hornblende granite or granite-diorite, with which it agrees in mineralogical composition.

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PLATE I. Foraminifera.

1. *Orbulina* cf. *universa*. Mag. $\frac{20}{1}$. From Div. 1, *b*, *2*, Hanford Brook. St. Martin's, N. B. See p. 109.
2. *Orbulina* (?) *ovalis*, n. sp. Mag. $\frac{20}{1}$. Same horizon. See p. 110.
3. *Orbulina intermedia*, n. sp. Mag. $\frac{10}{1}$. Same horizon. See p. 110.
4. *Orbulina ingens*, n. sp. Mag. $\frac{10}{1}$. Some horizon. See p. 110.
5. *Globigerina cambrica*, n. sp. Mag. $\frac{10}{1}$ —— 5*a*. With the initial chambers external —— 5*b*. Initial chambers internal —— 5*c*. Initial chambers broken out. All from Div. 1, *b*, *2*, Hanford Brook. See p. 111.
6. *Globigerina grandis*, n. sp. Mag. $\frac{5}{1}$. Three initial chambers broken off. Same horizon and locality. See p. 111 and see Errata.
7. *Globigerina didyma*, n. sp. Mag. $\frac{10}{1}$ —— 7*a*. Front view showing orifice —— 7*b*. Side view. Same horizon. See p. 111.
8. *Globigerina turrita*, n. sp. Mag. $\frac{40}{1}$ —— 8*a*. Section of complete shell? 8*b*. perhaps the same species, broken. Same horizon and locality. After W. D. Matthew. See p. 111.

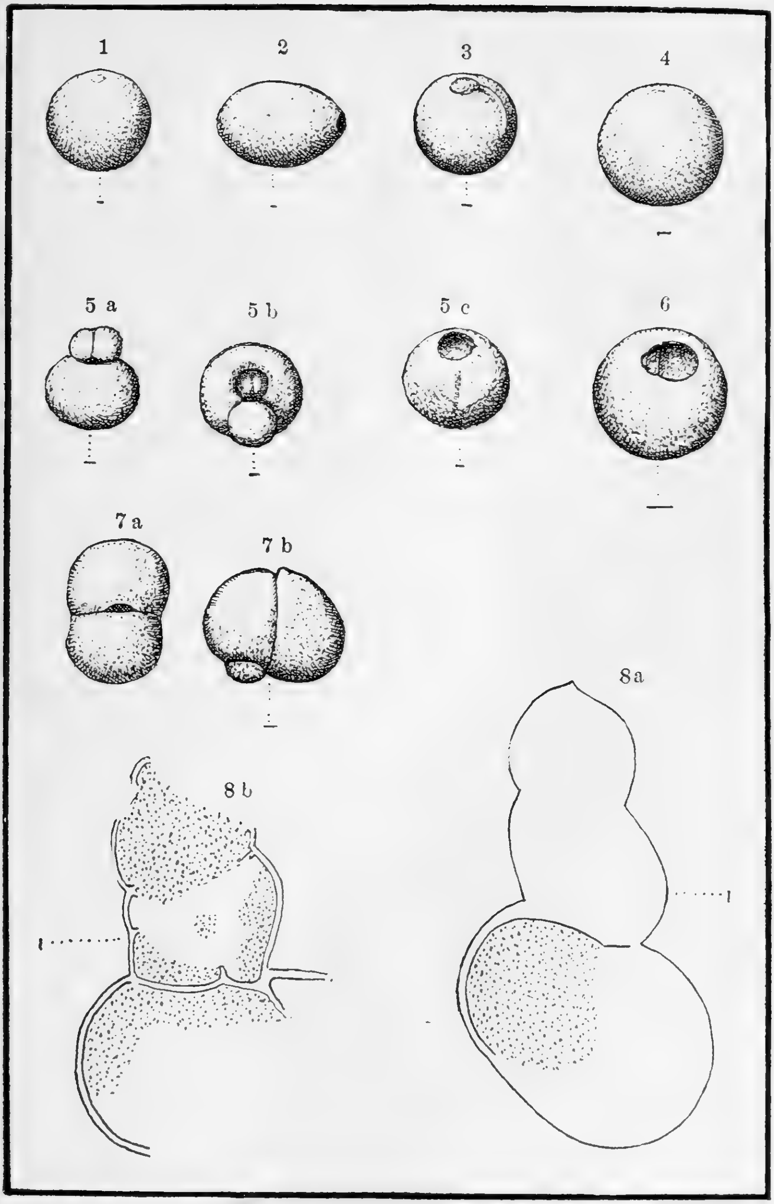

1
2
3
4
5 a
5 b
5 c
6
7 a
7 b
8a
8 b

PLATE II. SPONGIDA & BRACHIOPODA.

1. *Astrocladia* (?) *elongata*, Matt. Nat. Size. From Div. 1, *b.* at Belyea's Landing, Kings Co., N. B. See p. 113.
2. *Astrocladia* (?) *elegans*, Matt. Nat. Size. Same horizon.
3. *Astrocladia* (?) *virguloides*, Matt. —— *a.* Part of a branch, Nat. size, —— *b.* Same enlarged $\frac{10}{1}$ —— *c.* Same further enlarged to show spherules. From Div. 1, *b*, *2–4*, at Radcliff's mill stream. See p. 113.
4. *Dichoplectella*, sp. Mag. $\frac{10}{1}$. From Div. 1, *b*, 2–4, at Radcliff's stream. See p. 112.
5. *Protospongia*, sp. Mag. $\frac{4}{1}$. From Div. 1, *b*, *2*, Hanford Brook. See p. 112.
6. *Lingulella martinensis*, Matt. —— *a.* Ventral valve, Nat. size —— *b.* Obtuse mould of interior of ventral, showing cardinal area and furrow marking the place of the lateral and central scars. Mag. $\frac{3}{1}$ —— *c.* Acute variety, showing the same features. Mag. $\frac{4}{1}$ —— *d.* Interior of a dorsal valve showing low median ridge and place of cardinal muscle behind it. Mag. $\frac{3}{1}$. See p. 113.
7. *Lingulella* cf. *granvillensis* Walct. —— *a.* Ventral valve showing foraminal groove. Mag. $\frac{3}{1}$. From Div. 1, *b*, *1* and *2* —— *b.* Dorsal valve, interior of, showing impression of cardinal muscle and low central ridge marking place of central scars, which are well toward front of valve. Mag. $\frac{3}{1}$. From Div. 1, *b*, *3*. All from Hanford Brook. See p. 114.
8. *Obolella nitida* Ford —— *a.* Ventral valve partly exfoliated so as to show the impression of the lateral scars (crescent) Mag. $\frac{5}{1}$ —— *b.* Dorsal valve, indented where the median ridge exists within the shell. Mag. $\frac{6}{1}$. From Div. 1, *b*, *3*, Hanford Brook. See p. 125.

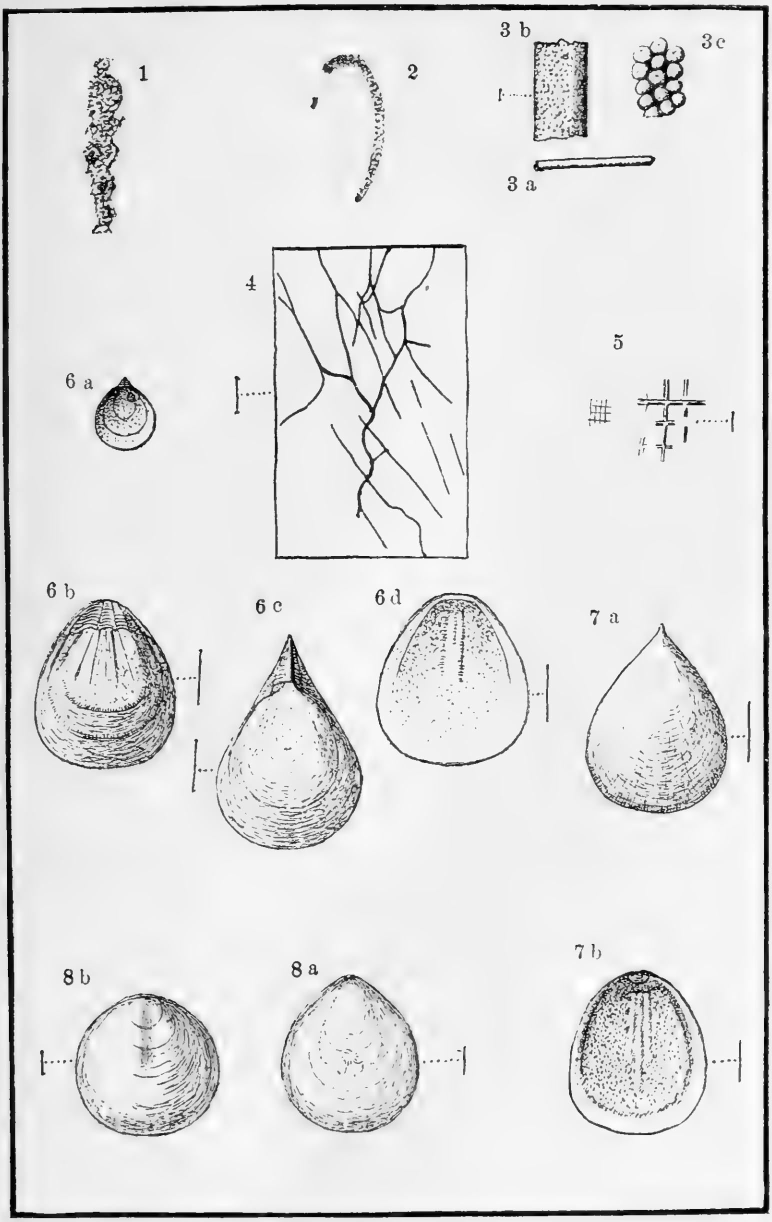

1
2
3 b
3 c
3 a
4
5
6 a
6 b
6 c
6 d
7 a
8 b
8 a
7 b

PLATE III. Botsfordia Pulchra.

1. *Botsfordia pulchra*, Matt. Dorsal valve —— *a.* Embryonic shell seen from above. Mag. $\frac{15}{1}$ —— *b.* Same seen from behind —— *c.* Same seen from the side —— *d.* Another embryonic shell with deeper previsceral depression, and revolute margin. Mag. $\frac{15}{1}$ —— *e.* Same in section —— *f.* Larval or næpionic shell, inner half shaded, with embryonic shell at the umbo. Mag. $\frac{5}{1}$ —— *g.* Adolescent or neologic shell, inner half shaded (embryonic and larval stages included). Mag. $\frac{3}{1}$ —— *h.* Adult or ephebolic shell showing all the stages and the outline of the visceral cavity, inner half shaded. Mag. $\frac{2}{1}$ —— *i.* Interior of the dorsal valve showing median and lateral ridges, and muscle scars. Mag. $\frac{2}{1}$ —— *k.* Another interior, showing cardinal muscle, laterals or adjustors, and the central muscles. Mag. $\frac{2}{1}$. See p. 115.
2. *Botsfordia pulchra*, Matt. Ventral valve —— *a.* Embryonic shell seen from above. Mag. $\frac{15}{1}$ —— *b.* Same seen from behind —— *c.* Same, side view, —— *d.* Complete larval or næpionic shell, with embryonic shell at the umbo. Mag. $\frac{5}{1}$——*e.* Complete adolescent or nealogic shell (embryonic and larval stages included). Mag. $\frac{3}{1}$ —— *f.* Adult or ephebolic shell showing all the stages of growth and the outline of the visceral cavity —— *g.* View of the hinge in the larval or næpionic stage showing a covered pedicle groove and foramen (?). Mag. $\frac{5}{1}$ —— *i.* Ventral valve decorticated in part, showing the place of the central muscles —— *k.* Interior of a ventral, showing the place of the cardinal, lateral and central muscles, radiating lateral ridges, hinge area, and flattened borders of the valve, etc. Mag. $\frac{2}{1}$ ——. All from Div. 1, *b*, *1–4*, Caton's Island. See p. 115.

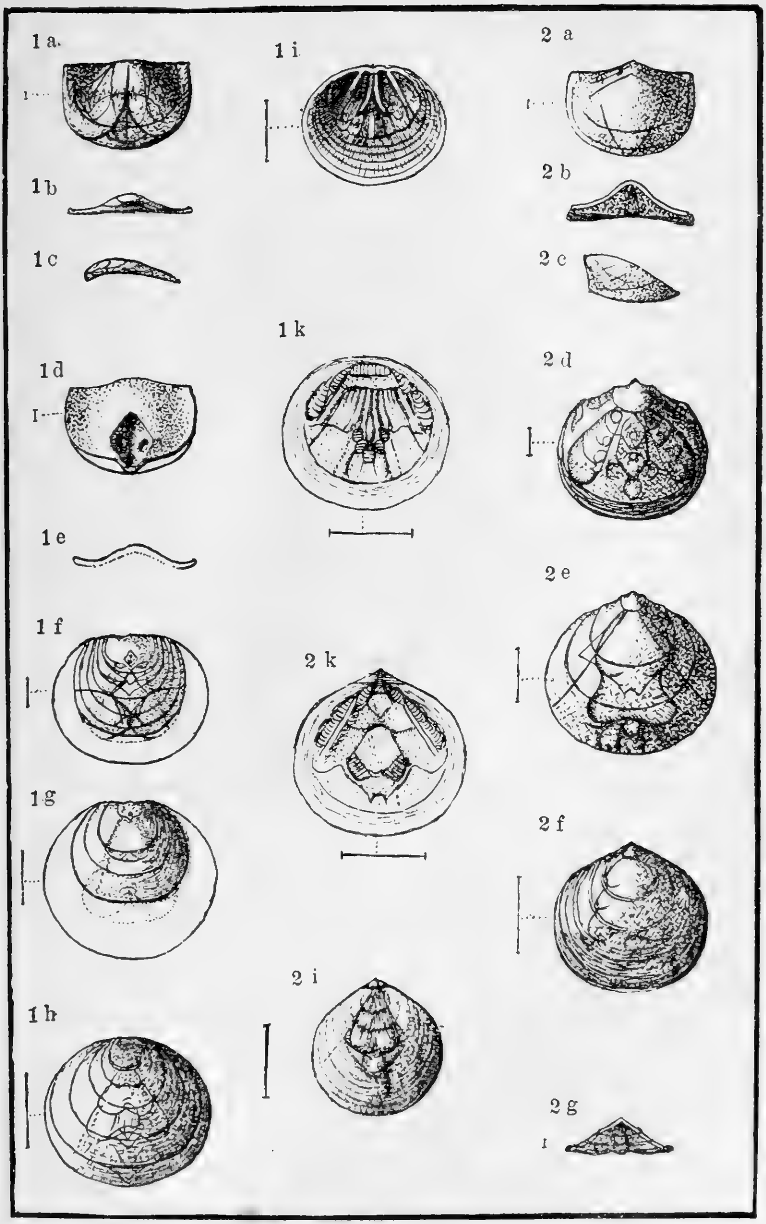

1 a.
1 b
1 c
1 d
1 e
1 f
1 g
1 h
1 i
1 k
2 k
2 i
2 a
2 b
2 c
2 d
2 e
2 f
2 g

PLATE IV. BRACHIOPODA.

1. *Obolus pristinus*, n. sp. —— *a.* Ventral valve showing remains of flange at the cardinal line. Mag. $\frac{2}{1}$ —— *b.* Same in profile —— *c.* Mould of interior of a ventral (supposed of this species) showing cardinal and lateral muscle pits and two lateral radiating grooves, also faint impressions of the central muscles, Mag. $\frac{2}{1}$ —— *d.* Same seen from behind. —— *e.* Mould of interior of a small dorsal valve (supposed of this species) showing pits for cardinal muscle and a crescent within the lateral muscle scars, also prints which appear to be of the central muscles, but are very far back. Mag. $\frac{4}{1}$. All from 1, *b*, *2*, Hanford Brook. See p. 121.
2. *Trematobolus insignis*, Matt. Mag. $\frac{4}{1}$ —— *a.* Interior of the ventral valve —— *b.* Interior of the dorsal valve —— *c.* Dorsal valve seen from behind —— *d.* Inside of beak of ventral valve (with hinge area removed). Notation of the muscles, &c. : *p. a.* posterior adductors ; *a. d.* adjustor muscles ; *l. m.* lateral muscles ; *a. p.* anterior depression ; *c. p.* cardinal pits ; *c.* cardinal process ; *o.* hinge socket ; *t.* dentiform process of the ventral valve ; *f.* foramen. From Div. 1, *b*, *2*, Hanford Brook. See p. 122.

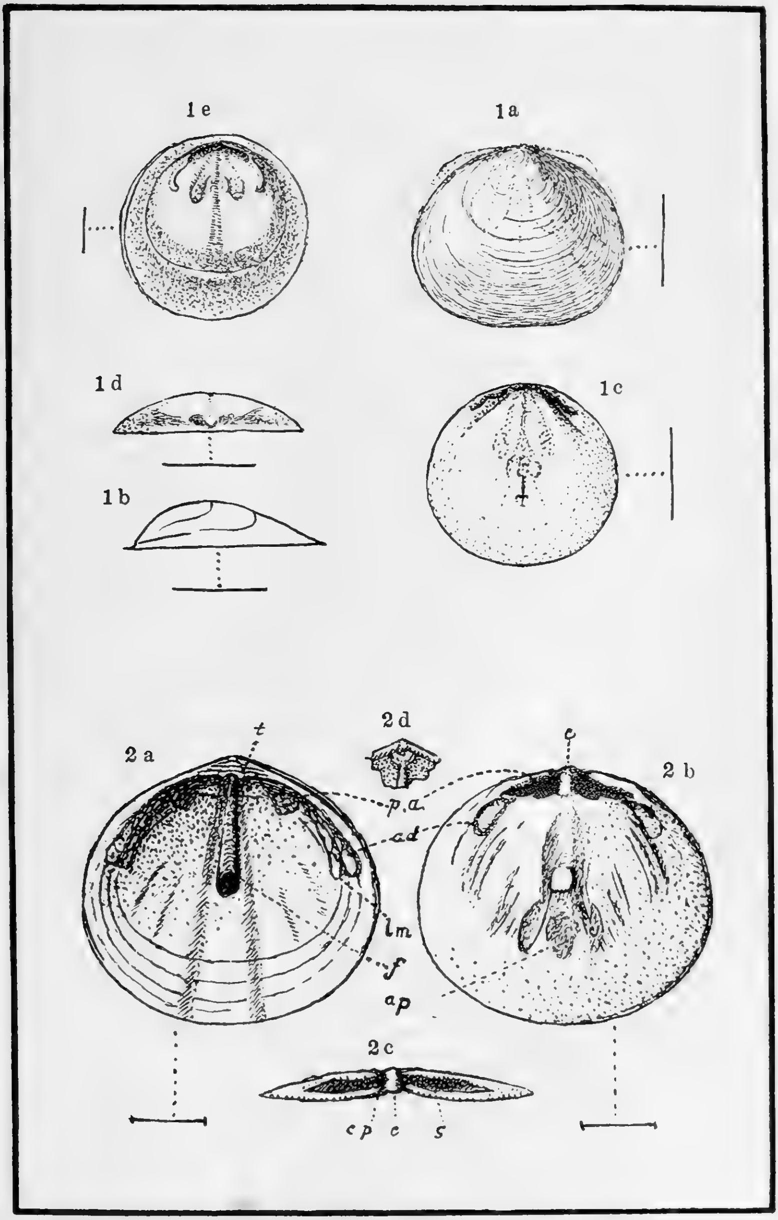

1 e
1 a
1 d
1 c
1 b
2 d
t
2 a
c
2 b
p.a.
ad
lm
f
ap
2 c
cp
c
s

PLATE V. Brachiopoda.

1. *Linnarssonia transversa*, Hartt. Dorsal valve. Mag. $\frac{5}{1}$ —— *a.* An example partly exfoliated, showing the forked median furrows, and median ridge ending in a rhombic protuberance, also showing the print of the muscles near the hinge —— *b.* Side view of the same —— *c.* View from behind. See p. 125.
2. *Linnarssonia transversa*, Hartt. Ventral valve. Mag. $\frac{5}{1}$ —— *a.* An example partly exfoliated, showing the apical boss, foramen and pit of the cardinal muscle —— *b.* Same, side view —— *c.* Same seen from behind. All from Hanford Brook. See p. 125.
3. *Lingulella* (?) *inflata*, Matt. Mag. $\frac{4}{1}$ —— *a.* Ventral valve —— *b.* Same in profile. From Div. 1, *b*, *1*, Hanford Brook. See p. 127.
4. *Lingulella* (?) *inflata*, var. *ovalis*, n. var. Mag. $\frac{4}{1}$ —— *a.* Ventral valve —— *b.* Apex enlarged to show mould of boss around the pedicle tube —— *c.* longitudinal section of this valve. From Div. 1, *b*, *1*, Hanford Brook. See p. 127.
5. *Acrotreta gemmula*, Matt. Mag. $\frac{12}{1}$ —— *a.* mould of the ventral valve, showing apical boss, foramen and arched ridges (crescent) around the interior of the valve —— *b.* Interior of dorsal valve, showing median septum and two pairs of scars ; the margin of the valve is revolute —— *c.* Ventral valve seen from behind, showing the area and the foramen opening under the break —— *d.* Side view of the same. From Div. 1, *b*, *3*, Hanford Brook. See p. 126.
6. *Acrothele Matthewi*, Hartt. Mag. $\frac{2}{1}$ —— *a.* Interior of the dorsal valve showing the mesian ridge, trifid in front where the central muscles were attached ; also showing pits of the cardinal muscles —— *b.* The same in profile. From Div. 1, *b*.
7. *Acrothele Matthewi*, Hartt var. *prima*. Mag. $\frac{2}{1}$ —— *a.* Ventral valve showing foramen near margin. From Div. 1, *b*, *3*, Hanford Brook.
8. *Acrothele Matthewi*, var. *lata*. Mag. $\frac{2}{1}$ —— *a.* Interior of ventral, anterior and lateral margins revolute ; two pits in front of the foramen, and four minute ones close to the hinge ; foramen more central. From Div. 1, *b*, *3*, Hanford Brook. See p. 128.
9. *Acrothele Matthewi*, var. *costata*, n. var. Mag. $\frac{4}{1}$ —— Ventral valve showing ridges and foramen. From Div. 1, *b*, *2*, and *5*, Hanford Brook. See p. 128.
10. *Orthid.* Small, indeterminable, dorsal valve. From Div. 1, *b*, *1*, Hanford Brook. See p. 128.

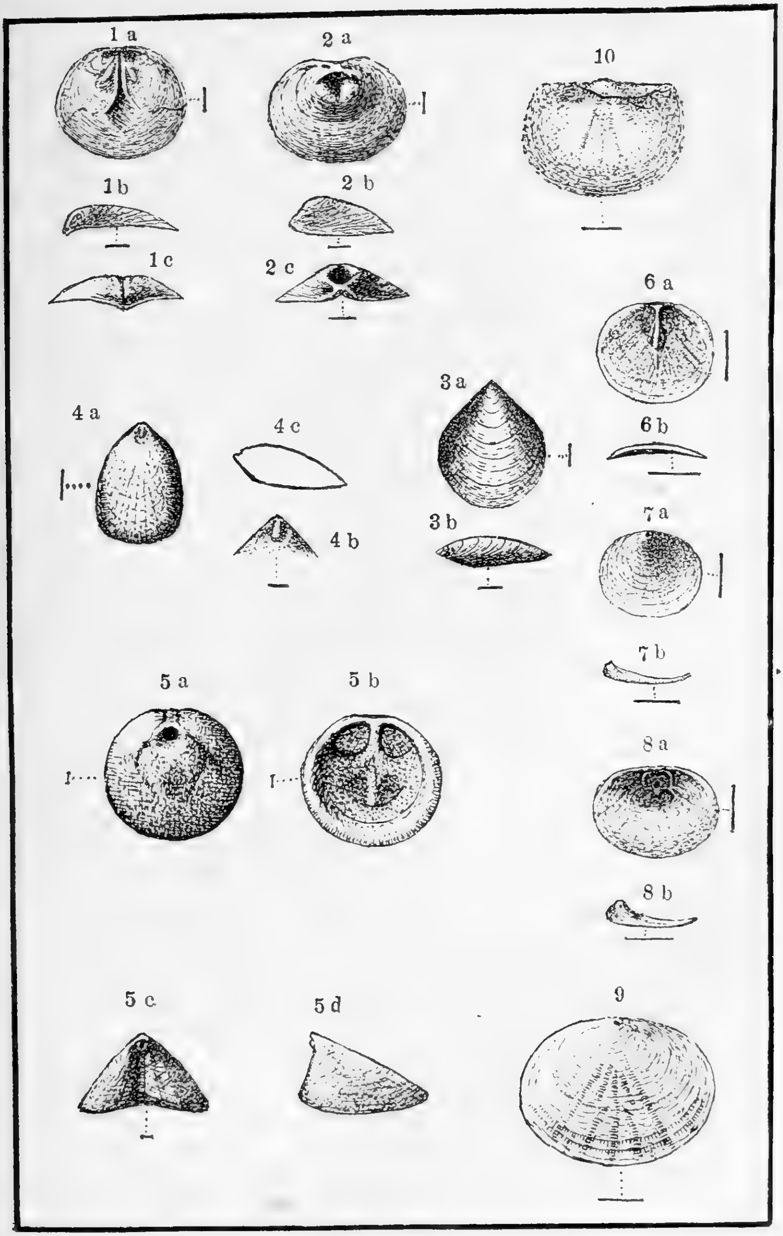

1 a
2 a
10
1 b
2 b
1 c
2 c
6 a
3 a
4 a
4 c
6 b
7 a
3 b
4 b
7 b
5 a
5 b
8 a
8 b
5 c
5 d
9

PLATE VI. Mollusca.

1. *Orthotheca* cf *Emmonsi*, Ford, Nat. size. Example with extremity decollated. Div. 1, *b*, *2*. Hanford Brook. See p. 129.
2. *Hyolithes decipiens*, Matt., Mag. $\frac{3}{1}$ ——*a*. Dorsal side ——*b*. Side view showing part of dorsal and of ventral sides —— *c*. Section near mouth —— *d*. Section near apex. From Div. 1, *b*, *2*, at Hanford Brook. See p. 130.
3. *Hyolithes gracilior*, n. sp. restored, Mag. $\frac{2}{1}$ —— *a*. Dorsal surface —— *b*. Side view showing angle at lip and curved apex. From Div. 1, *b*, *3*, Hanford Brook. See p. 130.
4. *Diplotheca acadica*, var. *crassa* Matt., Nat. size. Dorsal aspect shell, flattened and somewhat abraded showing the lateral edges of phragmated space beside the body cavity and a few septa near the apex of the shell. From Div. 1, *b*, *2*, Hanford Brook. See p. 130.
5. *Diplotheca hyattiana*, Matt., Mag. $\frac{4}{1}$ —— *a*. Dorsal aspect ; the shell abraded and showing septa near the apex, and diaphragms along the right side of the tube —— *b*. Side view, showing the curved proximate end of the tube —— From Div. 1, *b*, *3*, Hanford Brook. See p. 130.
6. *Pelagiella atlantoides*, n. gen. Mag. $\frac{4}{1}$ —— *a*. Seen from above —— *b*. View of the aperture —— *c*. Lower side of the shell, showing the umbilicus. From Div. 1, *b*, *2* and *3*, Hanford Brook. See p. 131.
7. *Volborthella tenuis*, Schmidt, Mag. $\frac{2}{1}$ —— *a*. Distal end showing a septum —— *b*. Smaller specimen showing septa. Both from Div. 1, *b*, *5*, Belyea's Landing, King's County, N. B. See p. 132.

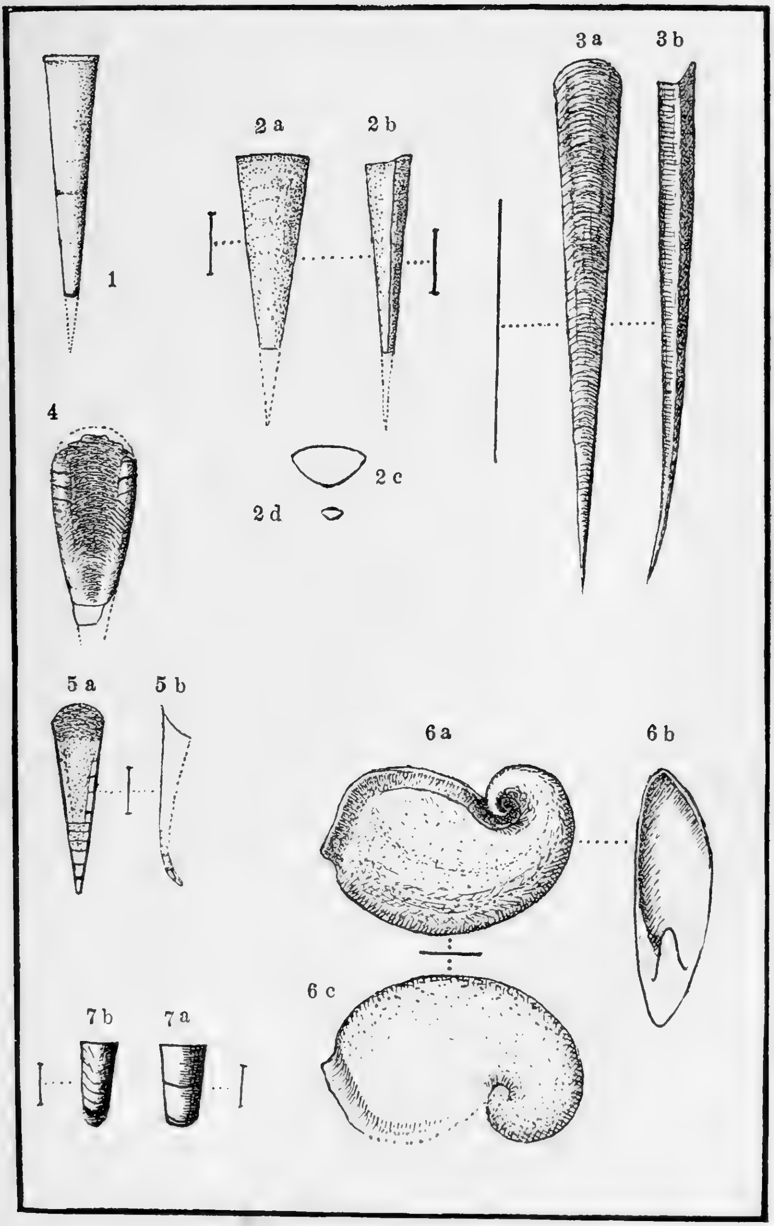

1
2 a
2 b
2 c
2 d
3 a
3 b
4
5 a
5 b
6 a
6 b
6 c
7 b
7 a

PLATE VII. Ostracoda.

1. *Hipponicharion Eos*, Matt. Mag. $\frac{4}{1}$ —— *a*. Right (?) valve, seen from above —— *b*. Transverse section near the hinge —— *c*. Longitudinal section of same. From Div. 1, *b*, *1*, Hanford Brook. See p. 132.
2. *Hipponicharion cavatum*, Matt. Mag. $\frac{4}{1}$ —— *a*. Left (?) valve, seen from above —— *b*. Transverse section near the hinge. From Div. 1, *b*, *1*, Hanford Brook. See p. 133.
3. *Hipponicharion minus*, Matt. Mag. $\frac{6}{1}$ —— *a*. Left (?) valve, seen from above —— *b*. Transverse section near the hinge. From Div. 1, *b*, *3*, Hanford Brook. See p. 133.
4. *Beyrichona papilio*, Matt. Mag. $\frac{4}{1}$ —— *a*. Both valves spread out —— *b*. Section near the posterior end —— *c*. Transverse section of vave near the hinge. From Div. 1, *b*, *4*, Hanford Brook. See p. 134.
5. *Beyrichona triangula*, n. sp. Mag. $\frac{4}{1}$ From Div. 1, *b*, *3*, also in 1, *b*, *2*, Hanford Brook. See p. 135.
6. *Beyrichona tinea*, Matt. $\frac{4}{1}$ —— *a*. Left valve, seen from above —— *b*. Transverse section near the hinge line —— *c*. Longitudinal section. From Div. 1, *b*, *4*, Hanford Brook. See p. 134.
7. *Beyrichona planata*, n. sp. Mag. $\frac{4}{1}$. Right valve. From Div. 1, *b*, *2*, Hanford Brook. See p. 134.
8. *Beyrichona ovata*, n. sp. Mag. $\frac{4}{1}$. Left (?) valve. From Div. 1, *b*, *2*, Hanford Brook. See p. 135.
9. *Beyrichona rotundata*, n. sp. Mag. $\frac{4}{1}$. Left valve. From Div. 1, *b*, *2*, Hanford Brook. See p. 136.
10. *Schmidtella cambrica*, n. sp. Mag. $\frac{6}{1}$. Left (?) valve. From Div. 1, *b*, *3*, Hanford Brook. See p. 137.
11. *Aparchites secunda*, n. sp. Mag. $\frac{4}{1}$ —— *a*. Left valve —— *b*. The two valves seen from the ventral side. From Div. 1, *b*, *3*, Hanford Brook. See p. 136.

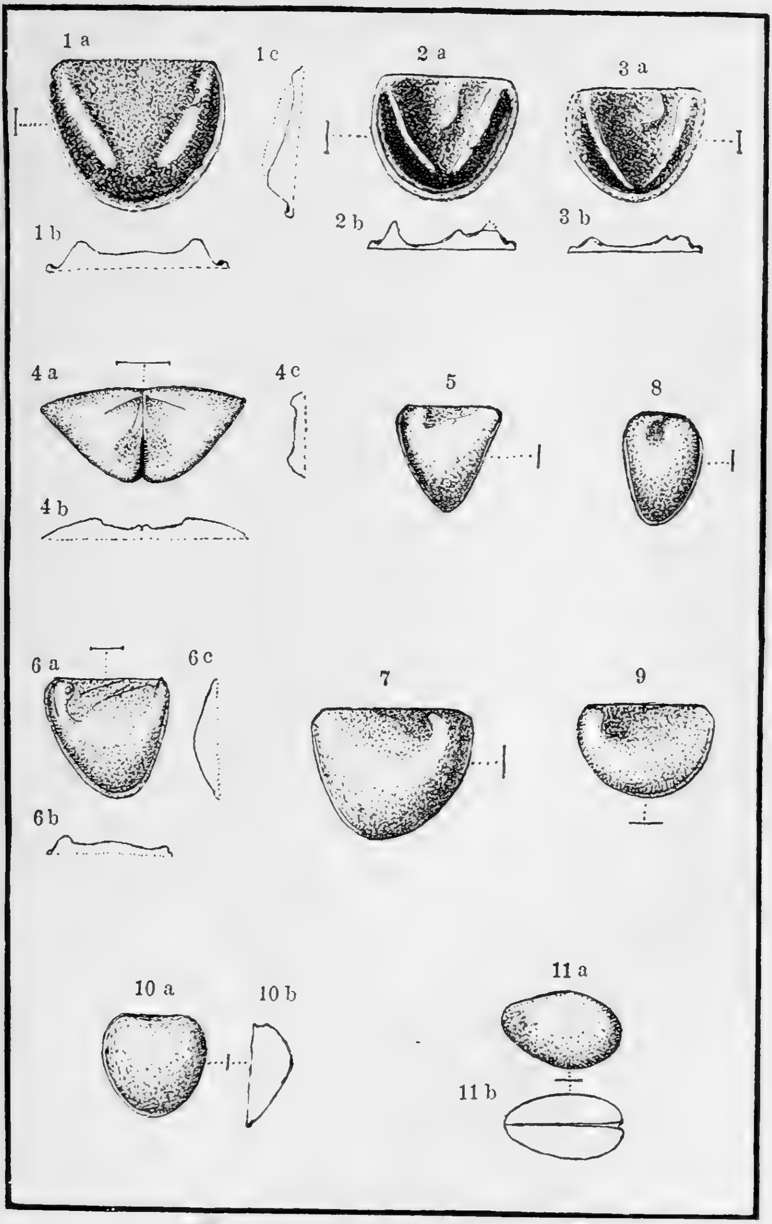

1 a
1 c
2 a
3 a
1 b
2 b
3 b
4 a
4 c
5
8
4 b
6 a
6 c
7
9
6 b
10 a
10 b
11 a
11 b

PLATE VIII. OSTRACODA (& PHYLLOPODA?).

1. *Primitia aurora*, Matt. Mag. $\frac{4}{1}$ —— *a.* Left valve, side view. —— *b.* horizontal section. —— *c.* vertical section. From Div. 1, *b*, *1*, Hanford Brook. See p. 136.
2. *Primitia oculata*, n. sp. Mag. $\frac{6}{1}$ —— *a.* Left valve, side view. —— *b.* Two valves from above. From Div. 1, *b*, *3*, Hanford Brook. See p. 136.
3. *Primitia* (?) *fusiformis*, n. sp. Mag. $\frac{4}{1}$ —— *a.* Right (?) valve —— *b.* Horizontal section. From Div. 1, *b*, *3*, Hanford Brook. See p. 137.
4. *Leperditia* (?) *minor*, n. sp. Mag. $\frac{6}{1}$ —— *a.* Left valve —— *b* vertical section. From Div. 1, *b*, *3*, Hanford Brook. See p. 138.
5. *Leperditia* (?) *ventricosa*, Matt. Nat. size —— *a.* Interior of right (?) valve —— *b.* Longitudinal section —— *c.* Vertical section —— *d.* Surface enlarged to show the sculpture. From Div. 1, *b*, *1*, Hanford Brook. See p. 137.
6. *Leperditia* (?) *primæva*, n. sp. Mag. $\frac{4}{1}$ —— *a.* Left valve —— *b.* Vertical section. Div. 1, *b*, *3*, Hanford Brook. See p. 138.
7. *Leperditia* (?) *Steadi*, Matt. Nat. Size —— *a.* Right (?) valve —— *b.* Horizontal section —— *c.* Vertical section. From Div. 1, *b*, *1*, Hanford Brook. See p. 137.
8. *Lepiditta sigillata*, Matt. Mag. $\frac{4}{1}$. Right valve. From Div. 1, *b*, *3*, Hanford Brook. See p. 138.

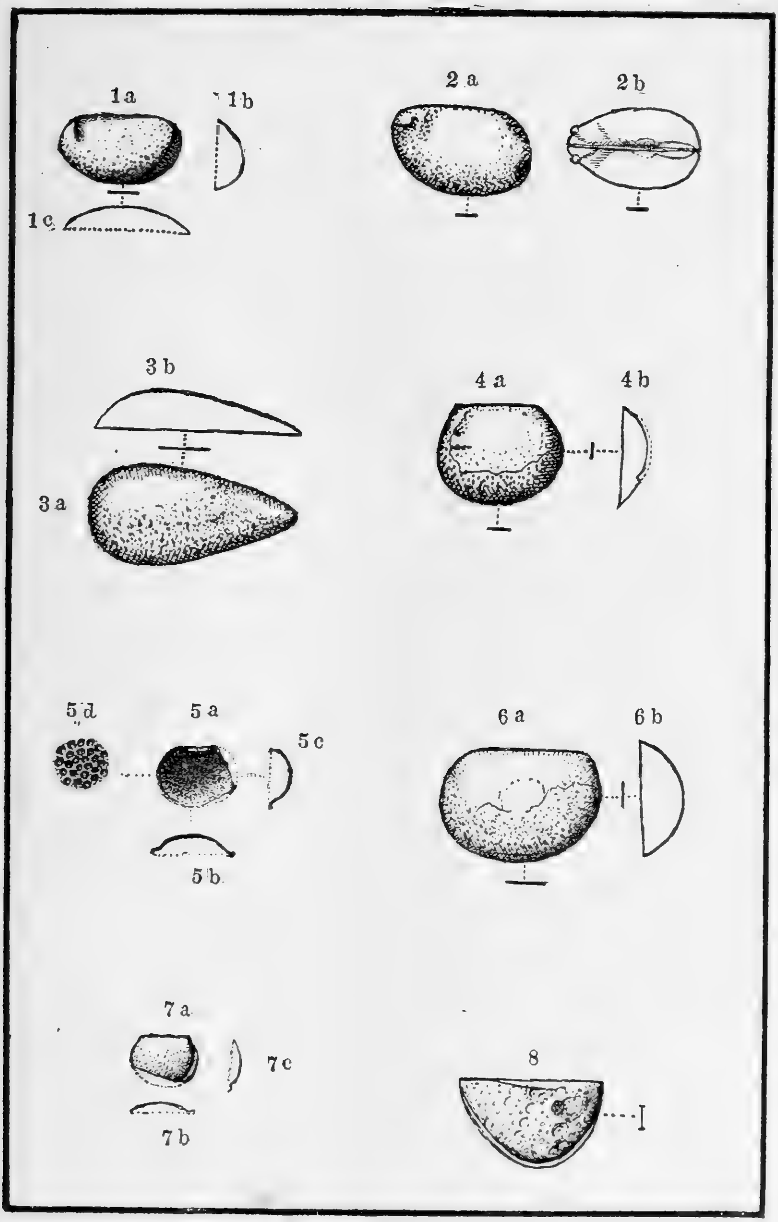

1a
1b
1c
2 a
2 b
3 b
3 a
4 a
4 b
5 d
5 a
5 c
5 b
6 a
6 b
7 a
7 c
7 b
8

PLATE IX. TRILOBITA.

1. *Protoagraulos priscus*, n. gen. et sp., Mag. $\frac{2}{1}$. Middle piece of the head shield. From Div. 1, *b*, *3*, Hanford Brook. See p. 139.
2. *Ellipsocephalus* cf. *polymetopus*, Linrs. Nat. size —— *a*. Middle piece of head shield —— *b*. Same side view —— *c*. Same from the front. From Div. 1, *b*, *1*, Hanford Brook. See p. 139.
3. *Ellipsocephalus grandis* Matt., Mag. $\frac{2}{1}$ —— *a*. Middle piece of the head shield —— *b*. A thoracic joint —— *c*. Head in profile. From Div. 1, *b*, *2*, Hanford Brook. See p. 140.
4. *Ellipsocephalus galeatus*, Matt., Mag. $\frac{2}{1}$ —— *a*. Middle piece of the head —— *b*. Movable cheek —— *c*. Head in profile —— *d*. Head with part of thorax —— *e*. Movable cheek —— *f*. A thoracic joint, sectioned. From Div. 1, *b*, *3*, Hanford Brook. See p. 139.
5. *Avalonia acadica*, n. sp. Mag. $\frac{4}{1}$. Head shield. From Div. 1, *b*, *3*, Hanford Brook. See p. 140.

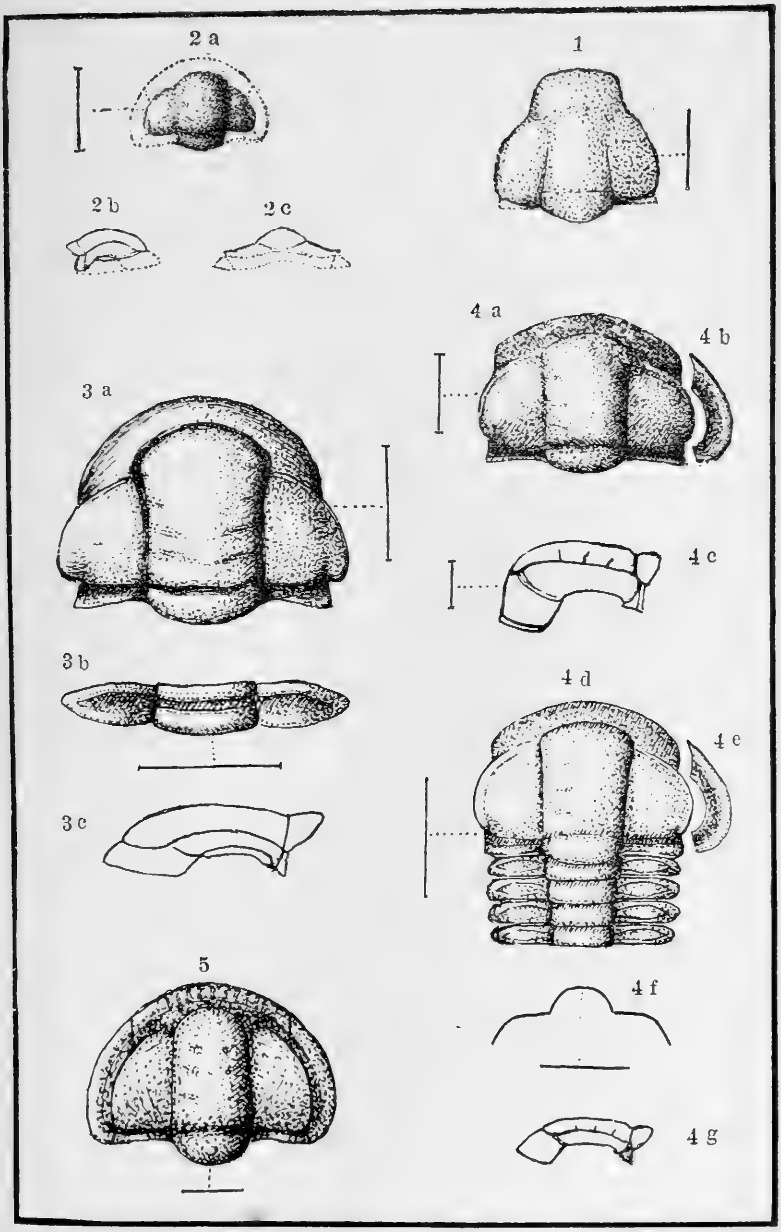

2 a
1
2 b
2 c
4 a
4 b
3 a
4 c
3 b
4 d
4 e
3 c
5
4 f
4 g

PLATE X. TRILOBITA.

1. *Micmacca Mattheri*, n. sp. Mag. $\frac{2}{1}$ —— *a*. Middle piece of the head shield —— *b*. Headshield in profile. From Div. 1, *b*, *3*, Hanford Brook. See p. 141.
2. *Micmacca recurva*, n. sp. Mag. $\frac{2}{1}$ —— *a*. Middle piece of the head —— *b*. Movable cheek. From Div. 1, *b*, *3*, Hanford Brook. See p. 142.
3. *Protolenus paradoxoides*, Matt. Nat. size, —— *a*. Middle piece of head shield ——*b*. Movable cheek —— *c*. Segment of thorax. From Div. 1, *b*, *3*, Hanford Brook. See p. 145.
4. *Protolenus bituberculatus*, n. sp. Nat. size. Middle piece of head defective, —— *b*. A joint of the thorax —— *c*. Same in profile. From Div. 1, *b*, *3*, Hanford Brook. See p. 145.
5. *Protolenus* (*Bergeronia*) *articephalus*, Matt. Mag. $\frac{2}{1}$ —— *a*. Middle piece of the head shield —— *b*. Same in profile. From 1, *b*, *3*, Hanford Brook. See p. 147.

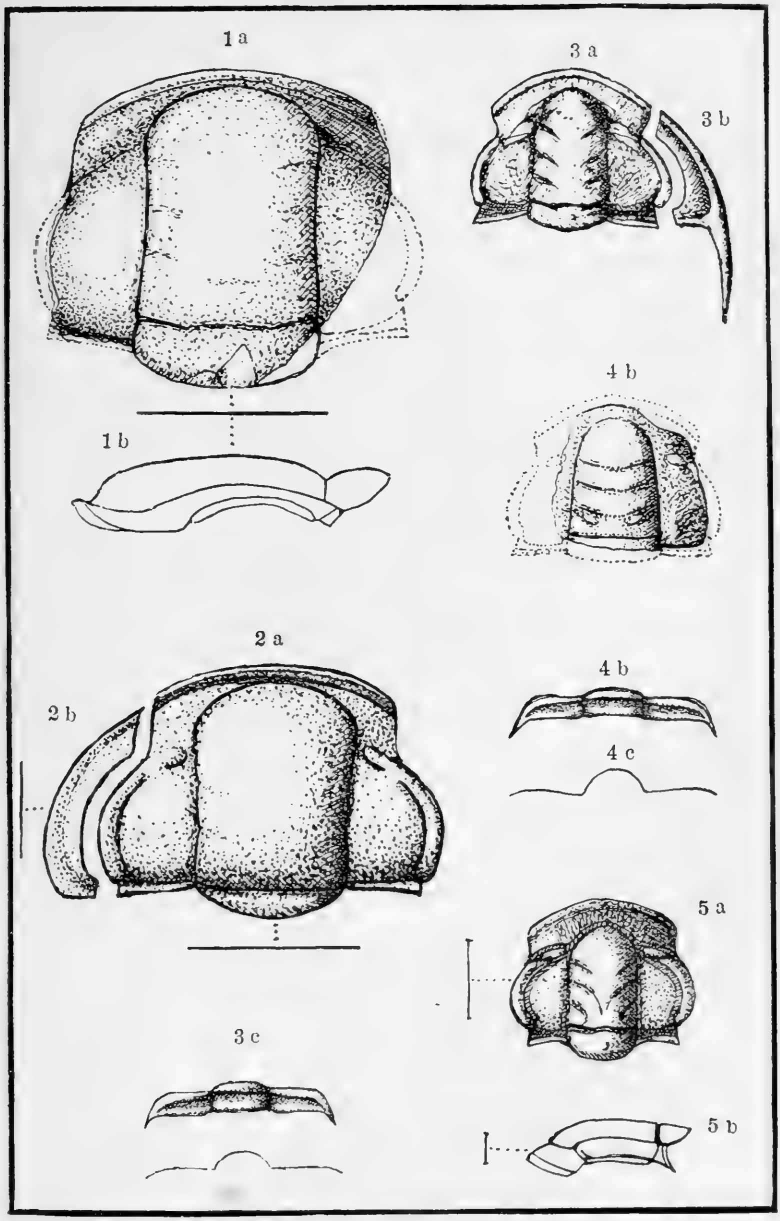

1 a
3 a
3 b
1 b
4 b
2 a
4 b
2 b
4 c
5 a
3 c
5 b

PLATE XI. Trilobita.

1. *Micmacca van Ingeni*, n. sp., Mag. $\frac{2}{1}$ —— *a.* Middle piece of the head shield —— *b.* Same in profile. From 1, *b*, *3*, Hanford Brook. See p. 142.
2. *Micmacca* (?) *plana*, n. sp., Mag. $\frac{2}{1}$ —— *a.* Middle piece of the head shield —— *b.* Same in profile. From 1, *b*, *3*, Hanford Brook. See p. 143.
3. *Protolenus* (*Bergeronia*) *elegans* Matt., Nat. size —— *a.* Middle piece of the head shield —— *b.* Movable cheek —— *c.* Head in profile —— *d*, Joint of the thorax —— *e.* Same in profile. From Div. 1, *b*, *2*, Hanford Brook. See p. 147.
4. "*Olenus*" *Zoppii* Mgh. Of the Cambrian of Sardinia, supposed to be a derivative from the same stock as Protolenus.

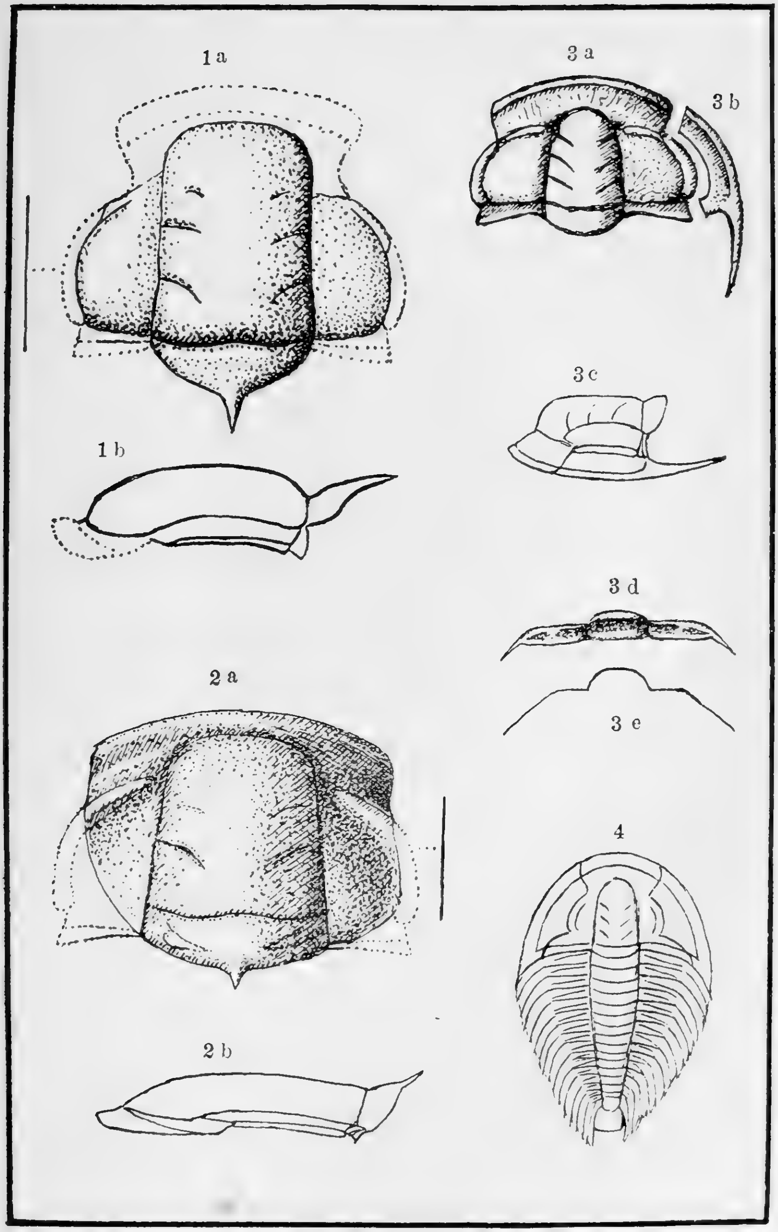

1 a
1 b
2 a
2 b
3 a
3 b
3 c
3 d
3 e
4

PLATE XII.

FIG. 1. *Spherulitic structure* in red felsite-porphyry (apobsidian) from the Hammond River below Upham, N. B. This section shows under higher magnification well preserved trichites throughout both the spherulitic and non-spherulitic parts of the rock (See Fig. 1, p 199). Spec. 664. Magnified 37 diameters.

FIG. 2. *Red felsite-porphyry* (trachyte), showing feldspar in three generations; large phenocrysts, small rod-like crystals and small grains not well bounded. The glassy material has been changed to micro-felsite. The only other minerals are magnetite and secondary limonite replacing in part one of the orthoclase phenocrysts. Spec. 575. $\times$ 42 diam.

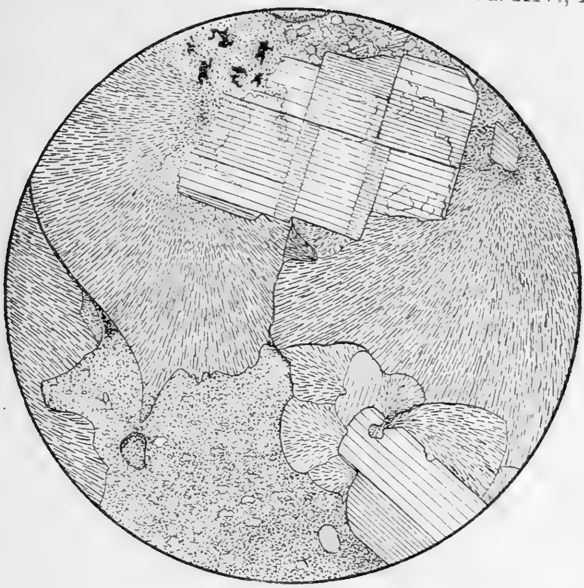


FIG. 1.

FIG. 2.

PLATE XIII.

FIG. 1. *Perlitic structure* in red felsite-porphyry (apobsidian) from Hammond River below Upham. The stippled part is microfelsite, which shows a flow-brecciated structure, the horizontal shading represents secondary quartz and feldspar. The perlitic cracks are in fact preserved in a brightly polarizing substance, but this was not easy to represent in the drawing. × 67 diam.

FIG. 2. *Skeleton crystals of magnetite* in black felsite porphyry (petrosilex) from Hanford Brook. Spec. 570. × 67 diam.

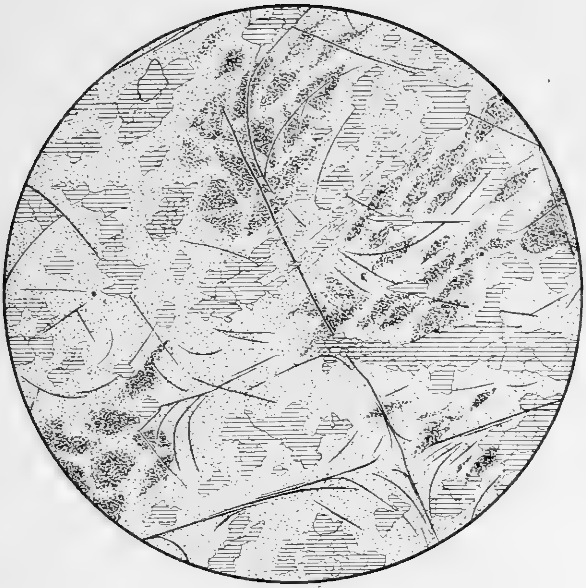


FIG. 1.

FIG. 2.

PLATE XIV.

FIG. 1. *Diorite-porphyrite*, coarse grained. The hornblende is represented by heavy shading; the feldspar is lightly shaded. An attempt is also made to represent the zonal structure and decayed cores of the phenocrysts. The quartz is unshaded and the magnetite is dead black. Spec. 608. × 37 diam.

FIG. 2. *Diorite-porphyrite*, fine-grained. The shading is the same as in Fig. 1; it shows in addition a well marked flow-structure, and quartz as phenocryst; the quartz in the groundmass is not represented, nor are the feldspar individuals distinguished. × 30 diam.

FIG. 1.

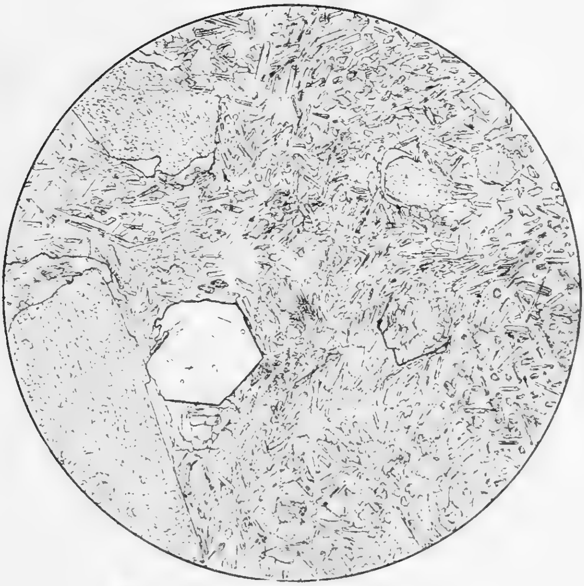


FIG. 2.

PLATE XV.

FIG. 1. *Fine-grained Norite.* A phase of the olivine-gabbro at Dolin's Lake. Biotite is represented by heavy parallel lines, plagioclase by light ones; augite and hypersthene by irregular cracks, the hypersthene sometimes showing schillerization with innumerable minute parallel rods of magnetite. Spec. 473. × 77 diam.

FIG. 2. *Quartz-bearing diabase* from west of the Coldbrook Marsh. The feldspar is shaded with parallel lines, the augite by irregular ones, the magnetite being black and the quartz unshaded. The abundant apatite needles are too small to be shown in the figure. Spec. 304. × 20 diam.

FIG. 1.

FIG. 2.

PLATE XVI.

FIG. 1. *Soda-granite*, from Titus' Mill. The feldspar is stippled, the fine twinning of the anorthoclase, being represented where visible by parallel lines. Some attempt is made to show the comparative alteration of the feldspar by the heaviness of the stippling. Hornblende is represented by diagonally crossing parallel lines. Quartz is unshaded and magnetite is dead black. Spec. 661. × 18 diam.

FIG. 2. *Soda-granite* fine grained and porphyritic. From the Hammond River below Upham. Shading as in the last figure, but augite is represented by irregular lines. Spec. 666. × 37 diam.

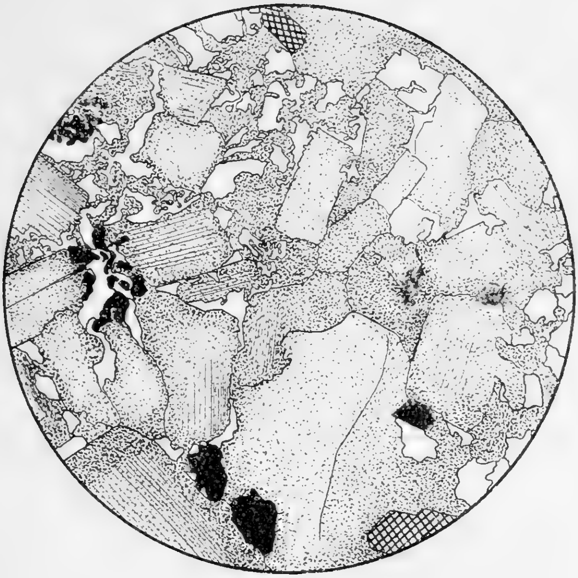


FIG. 1.

FIG. 2.

PLATE XVII.

FIG. 1. *Granophyric structure* in soda-granite from near Hardingville. The feldspar is represented by parallel horizontal lines; the quartz is unshaded; the hornblende is represented by diagonally crossing lines, zircon by irregular heavy cracks, and chlorite by arrow points. In the upper left hand quadrant the quartz is mostly in minute trigonal prisms variously shown by different sections. In the upper right hand quadrant the quartz is regular and minute at the centre, but becomes coarse and irregular outside. In the lower half the quartz is seen radiating out from a crystal of feldspar, becoming coarser and more irregular as it continues its growth. The feldspar between these quartz growths is in part optically continuous with the central crystal. From Spec. 656. × 80 diam.

FIG. 1.

PLATE XVIII.

Right upper extremity.
♀, white, U. S. aet. 62.
Gleno-ulnar head ; var. 1, Capsulo-pectoral tendon.

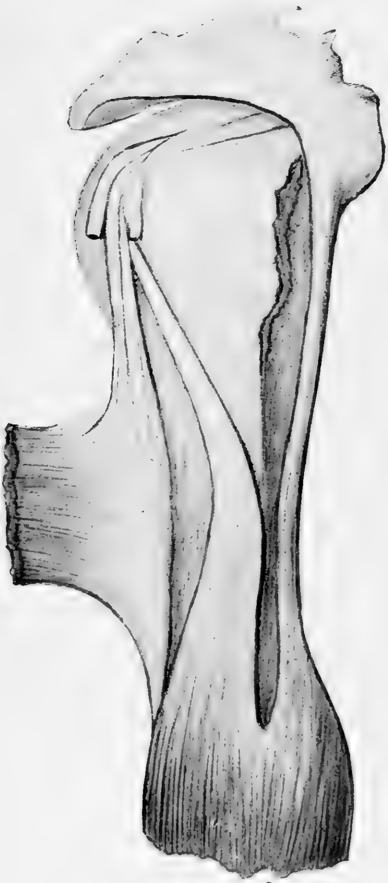


PLATE XIX.

Right shoulder joint of same subject, opened from behind, head of humorus removed, showing thickening of anterior capsule wall by the Capsulo-pectoral tendon.

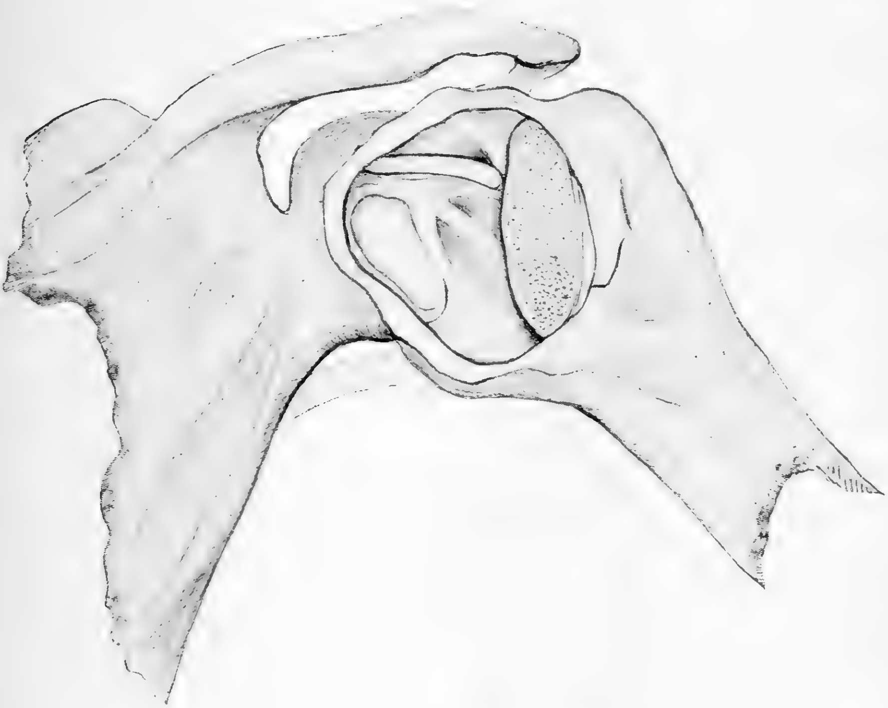


PLATE XX.

Right upper extremity.
♂, Austria, aet. 65.
Gleno-ulnar head ; var. 1, Capsulo-pectoral tendon.

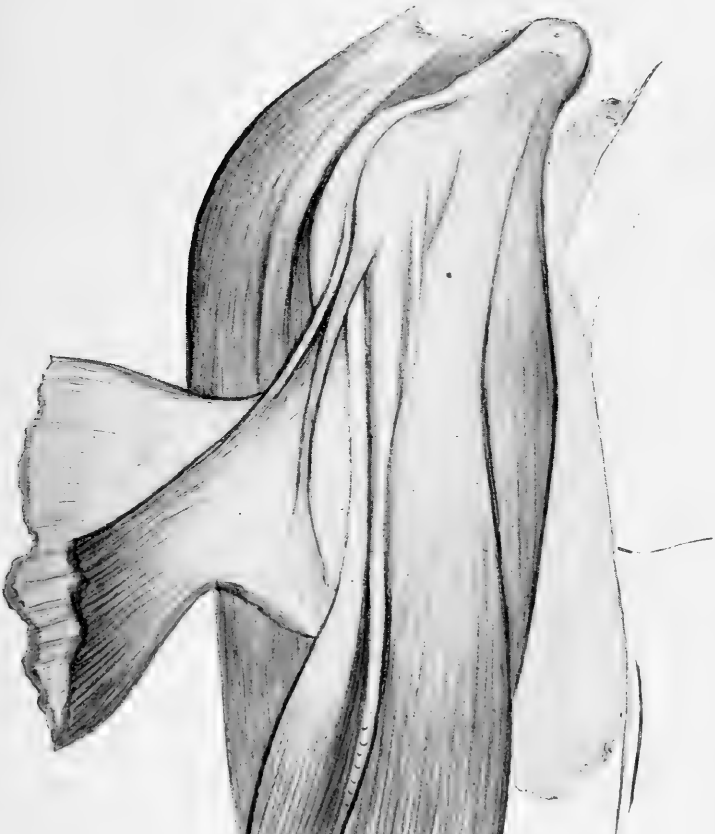


PLATE XXI.

Right upper extremity.
♀, Germany, aet. 84.
Gleno-ulnar head, var. 1, Capsulo-pectoral tendon.

PLATE XXII.

Right upper extremity.
♂, U. S. white, aet. 24.
Gleno-ulnar head, var. 2a, Gleno-ulnar muscle.

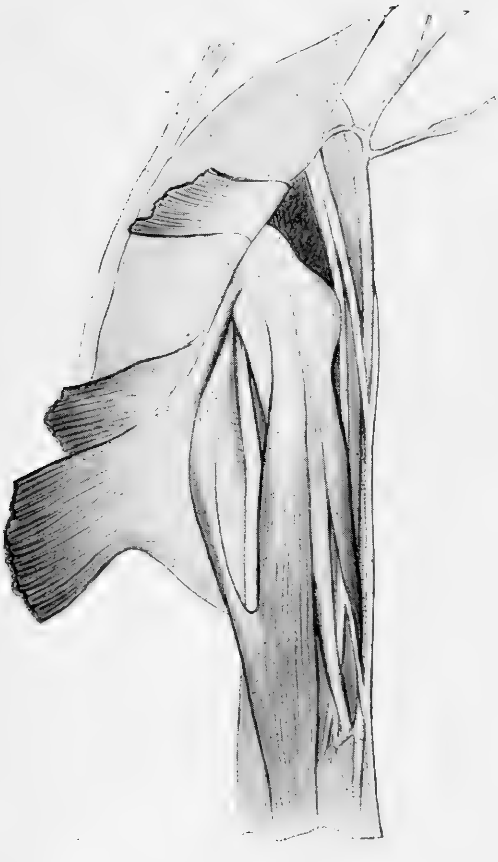


PLATE XXIII.

Right upper extremity.
♂, U. S. white, aet. 50.
Gleno-ulnar head, var. 2a, Gleno-ulnar muscle.

PLATE XXIV.

Right upper extremity.
♂, U. S. negro, aet. 50.
Gleno-ulnar head, var. 2a, Gleno-ulnar muscle.

PLATE XXV.

Left upper extremity.
♀, U. S. white, aet. 23.
Gleno-ulnar head, var. 2a, Gleno-ulnar muscle.

PLATE XXVI.

Left upper extremity.
♂, U. S. negro, aet. 50.
Gleno-ulnar head, var. 2b, Gleno-ulnar muscle.

PLATE XXVII.

Right upper extremity.
♂, Ireland, aet. 32.
Gleno-ulnar head, var. 2b, Gleno-ulnar muscle.

PLATE XXVII.

Right upper extremity.
♂, Ireland, aet. 32.
Gleno-ulnar head, var. 2b, Gleno-ulnar muscle.

PLATE XXVIII.

Left upper extremity of preceding subject.
♂, Ireland, aet. 32.
Gleno-ulnar, head, var. 2a, Gleno-ulnar muscle.

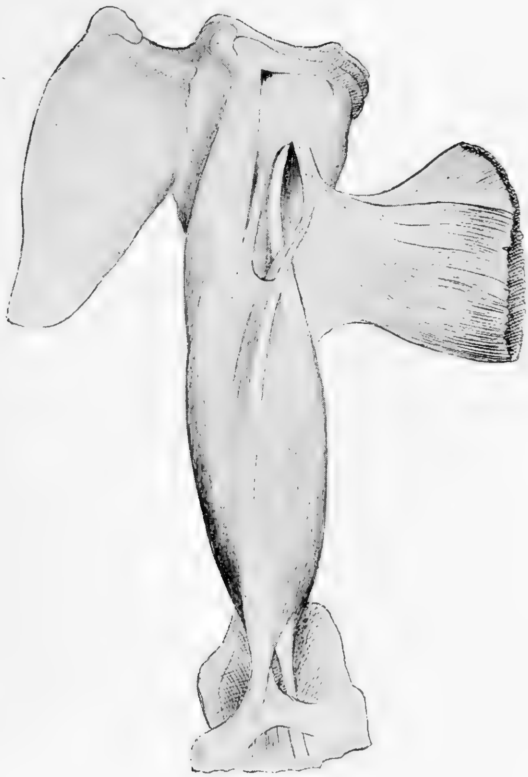


PLATE XXIX.

Left upper extremity.
♂, Ireland, aet. 53.
Gleno-ulnar head, var. 2c, transition forms and variations.

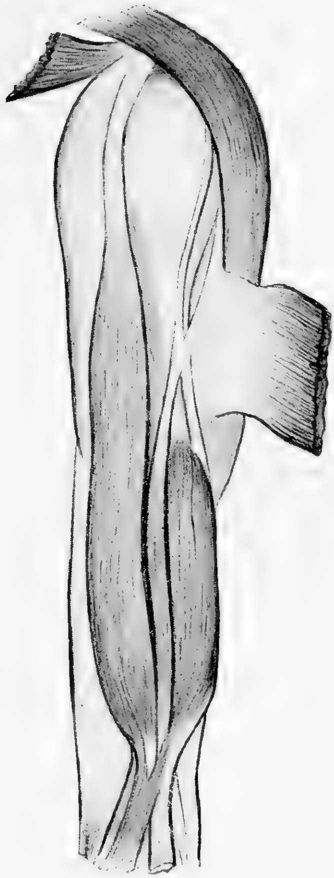


PLATE XXX.

Left upper extremity.
♂, Ireland, aet. 35.
Gleno-ulnar head, var. 2c, transition forms and variations.

PLATE XXXI.

Right upper extremity.
♂, Germany, aet. 64.
Gleno-ulnar head, var. 2c, transition forms and variations.

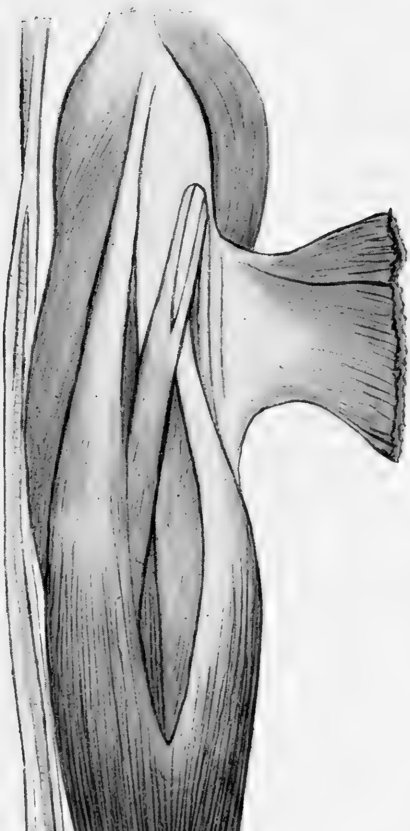


PLATE XXXII.

Left upper extremity.
♂, Germany, aet. 66.
Gleno-ulnar head, var. 3, Gleno-epitrochlear tendon.

PLATE XXXIII.

Left upper extremity.

♂, Ireland, aet. 42.

Gleno-ulnar head, var. 3, Gleno-epitrochlear tendon.

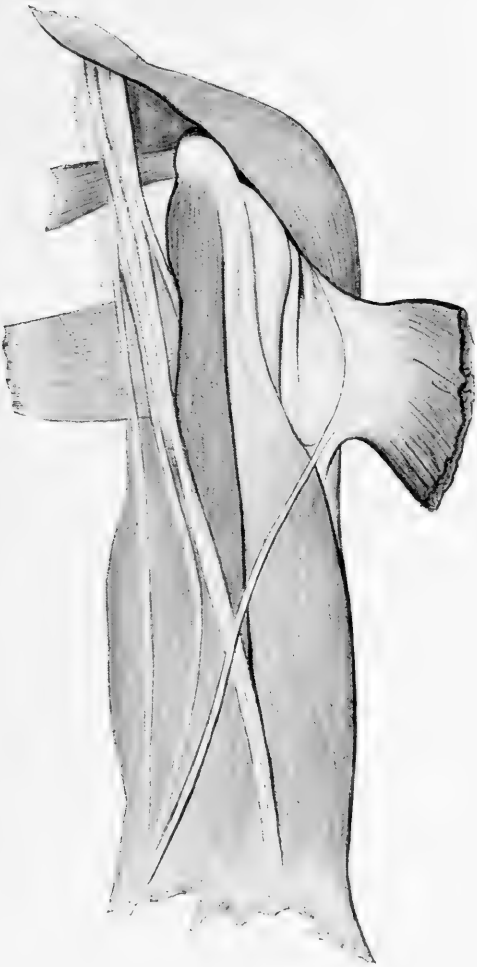


PLATE XXXIV.

Right upper extremity.
♀, Ireland, aet. 27.
Gleno-ulnar head, var. 4, M. Brachio-ulnaris lateralis.

PLATE XXXV.

Right upper extremity.
♀, U. S. negro, aet. 24.
Gleno-ulnar head, var. 4, M. Brachio-ulnaris lateralis.

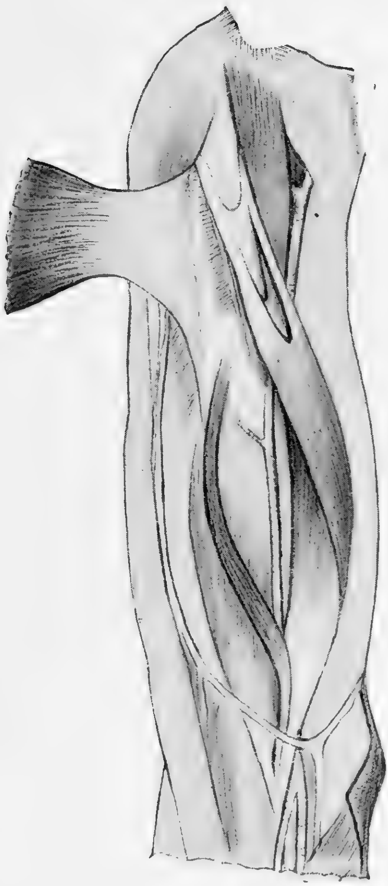


PLATE XXXVI.

Right upper extremity.

♀, Ireland, aet. 72.

Gleno-ulnar head, var. 6, combination of tendinous Gleno-ulnar and Coraco-epitrochlear.

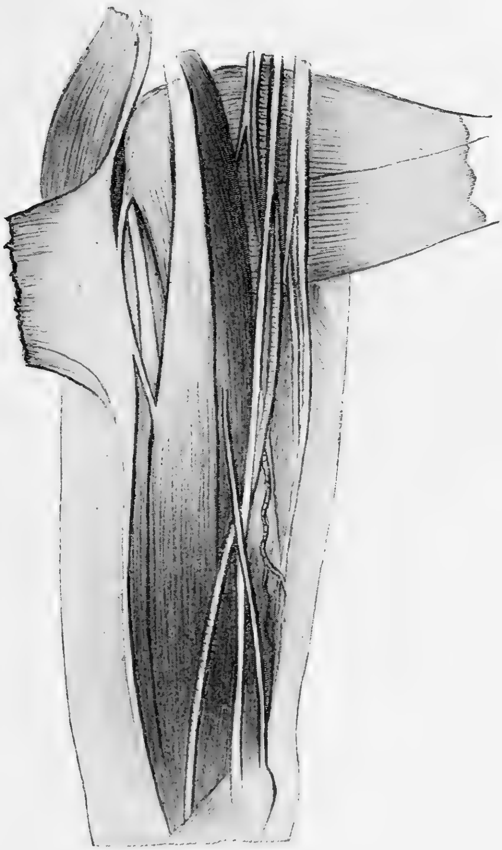


PLATE XXXVII.

Right upper extremity.
♂, U. S. white, aet. 47.
Coraco-ulnar head, var. 2a, Coraco-epitrochlear tendon.

PLATE XXXVIII.

Right upper extremity.

♂, U. S. white, aet. 46.

Coraco-ulnar head, var. 2b, Coraco-epitrochlear and Gleno-epitrochlear tendons combined.

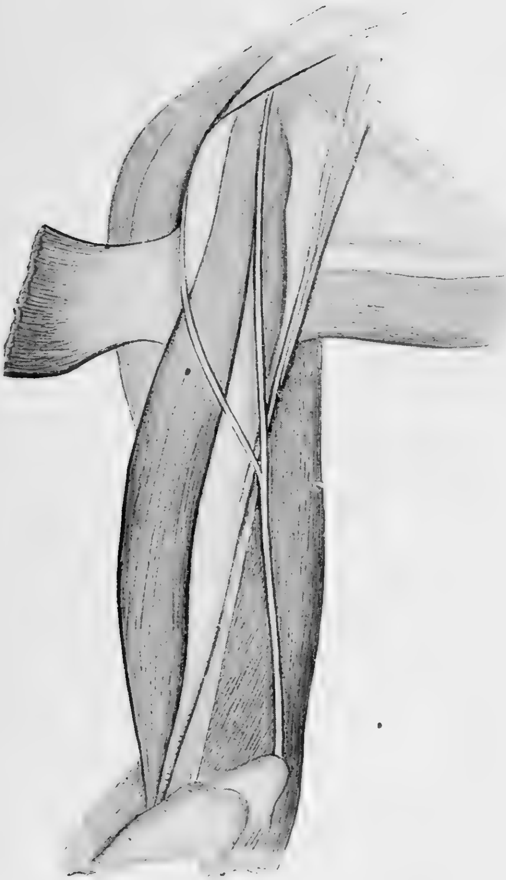


PLATE XXXIX.

Left upper extremity.
♂, Germany, aet. 29.
Coraco-ulnar head, var. 2c, M. Coraco-epitrochlearis.

PLATE XL.

Right upper extremity.
♂, Ireland, aet. 45.
M. Quadriceps flexor cubiti.

PLATE XLI.

Right upper extremity.
♂, Ireland, aet. 40.
M. Quadriceps flexor cubiti.

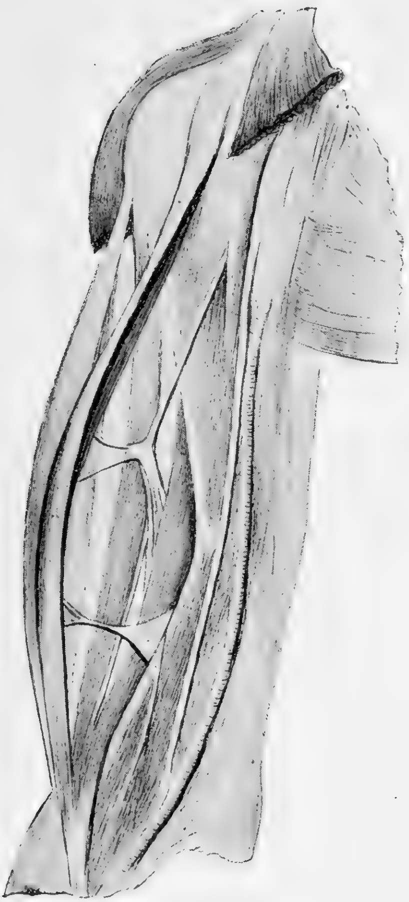


PLATE XLII.

Right upper extremity.

♂, Germany, aet. 62.

M. Quadriceps flexor cubiti.

PLATE XLIII.

Right upper extremity.
♂, U. S. white, aet. 63.
M. Quadriceps flexor cubiti.

PLATE XLIV.

Left upper extremity.
♀, U. S. white, aet. 26.
M. Quadriceps flexor cubiti.

PLATE XLV.

Right upper extremity.
♂, Assyria, aet. 28.
M. Brachialis accessorius, joining insertion of Biceps.

PLATE XLVI.

Left upper extremity.

♂, Ireland, aet. 67.

Gleno-ulnar and Coraco-ulnar muscles, complete form, with distal portions persistent.

PLATE XLVII.

Right upper extremity.

♀, Ireland, aet. 54.

Connection of Biceps and Brachialis anticus, with complete derivation of semilunar fascia from the latter muscle.

EXPLANATION OF PLATE XLVIII.

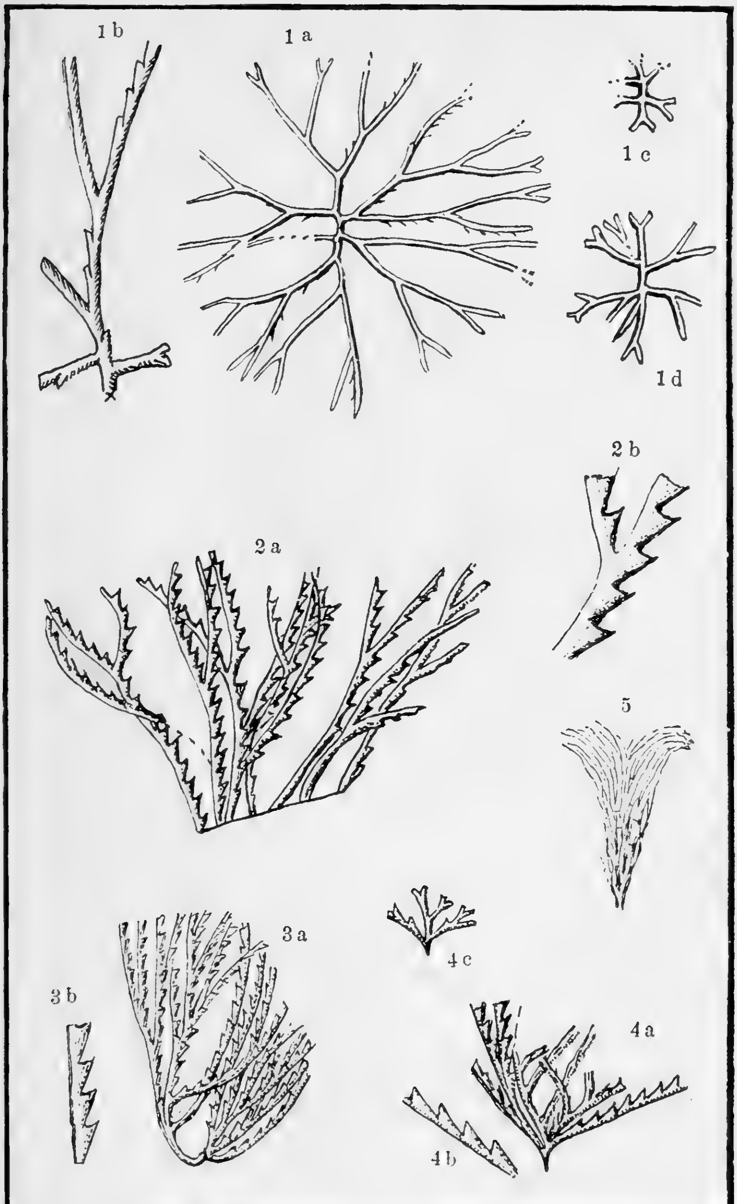
FIG. 1. *Clonograptus proximatus* n. sp.——*a*. Hydrosome, mag. $\frac{2}{1}$——*b*. Upper branch on the patent side, mag. $\frac{4}{1}$ to show the cells.——*c*. Young hydrosome, mag. $\frac{2}{1}$ showing secondary branches——*d*. Young hydrosome, mag. $\frac{2}{1}$ showing tertiary and quarternary branches. From. Div. 3 *c*, Navy Id. See p. 265.

FIG. 2. *Bryograptus lentus* n. sp.——*a*. hydrosome (part) mag. $\frac{2}{1}$——*b*. Branch enlarged to show cells. Mag. $\frac{4}{1}$. From Div. 3*c*, Navy Id. See p. 270.

FIG. 3. *Bryograptus spinosus* Matt.——*a*. hydrosome, mag. $\frac{2}{1}$——*b*. Branch enlarged to show cells. Mag. $\frac{4}{1}$. From Div. 3*c*, Navy Id. See p. 269.

FIG. 4. *Bryograptus patens* Matt.——*a*. hydrosome, mag. $\frac{2}{1}$——*b*. Branch enlarged to show cells. Mag. $\frac{4}{1}$——*c*. Young hydrosome, mag. $\frac{2}{1}$, showing quarternary branches. From Div. 3*e*, Navy Id. See p. 268.

FIG. 5. *Callograptus* sp. Mag. $\frac{2}{1}$. From Div. 3*c*, Navy Id. See p. 271.

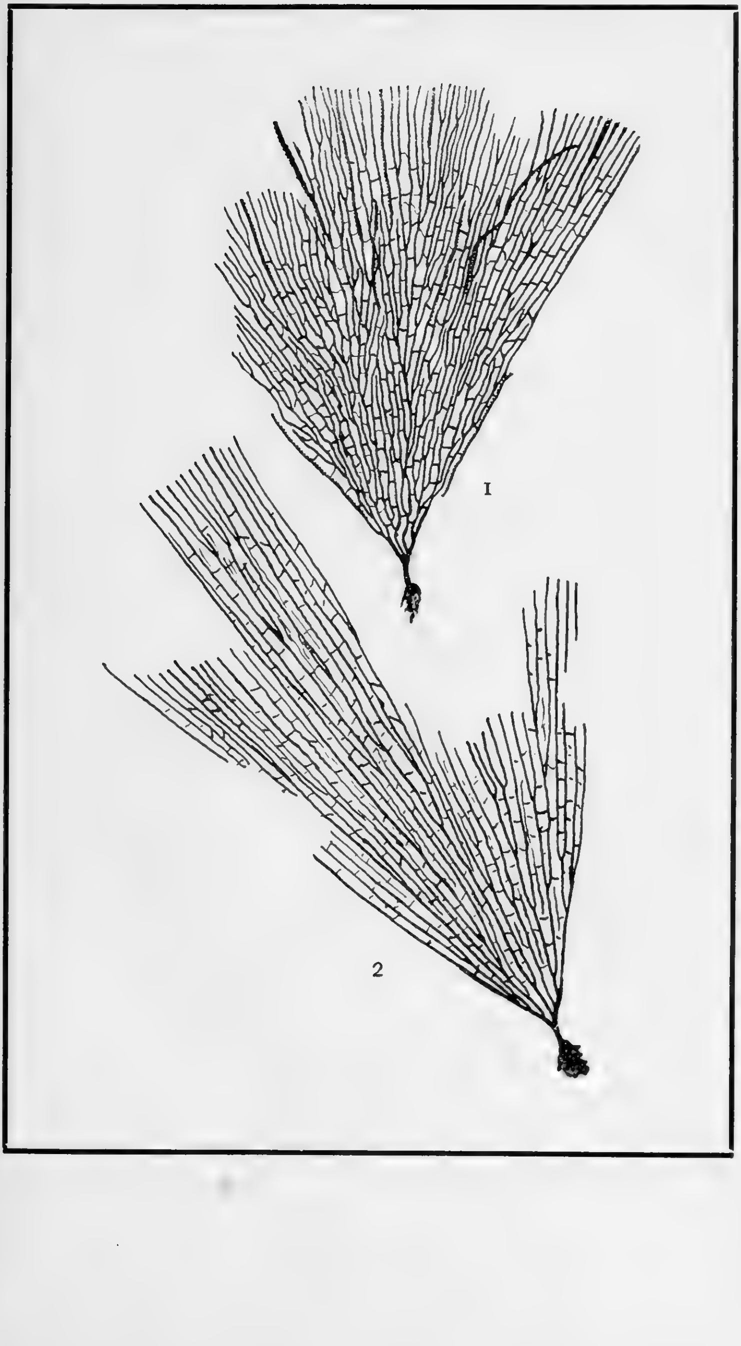

1 b
1 a
1 c
1 d
2 b
2 a
5
3 a
4 c
3 b
4 a
4 b

EXPLANATION OF PLATE XLIX.

FIG. 1. *Dictyonema flabelliforme* Eichw. Hydrosome. Nat. size. Showing the root-like extension of the proximate end of the hydrosome.

FIG. 2. A larger example of the same variety. Both from Div. 3*c*, Navy Island, St. John Harbor.

N. B.—These figures were traced by Mr. Gilbert van Ingen from a photograph.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New York
Academy of Sciences

CATALOGUE

OF EXHIBITS

March 13th, 1895

New York

Academy of Sciences

SECOND

ANNUAL RECEPTION

And Exhibit of Recent Progress in Science, in the

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215 West 57th Street

March 13th, 1895

The Knickerbocker Press, New York

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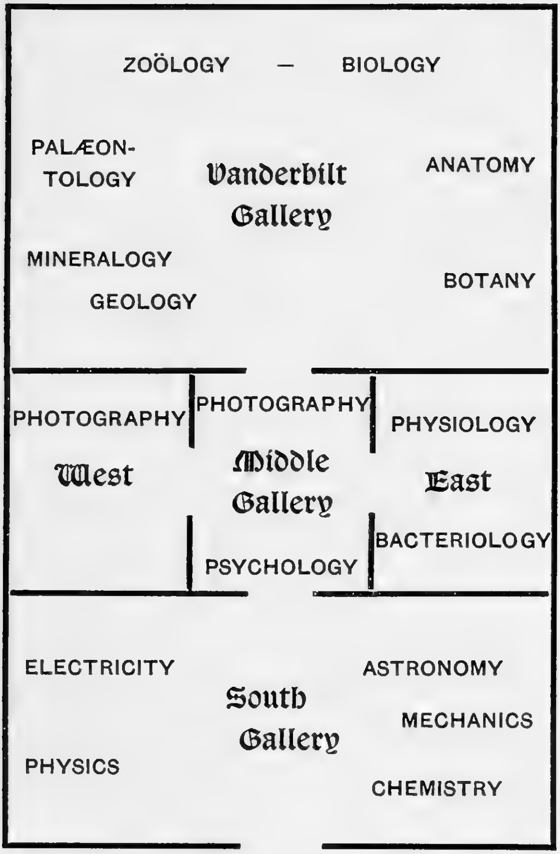
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In charge of Prof. Alfred M. Mayer.

1. DIVIDED CIRCLE, and mechanism giving the angle of refraction for any angle of incidence.

2. DIVIDED CIRCLE, and mechanism giving the angle of refraction for any angle of incidence, and showing the directions of the incident and refracted rays.

3. A series of CHLADNI FIGURES preserved in sand by Prof. Mayer's process. Illustrating the vibrations of plates, and the errors of older figures, and the coincidence between the present figures and Lord Rayleigh's theoretical deductions.

4. POLARISCOPE with special lenses, giving very large field for work on crystals.

Nos. 1 to 4 are exhibited by Prof. A. M. Mayer.

5. ABBE REFRACTOMETER for determining the index of refraction and dispersion of liquids at various temperatures.

6. KOHLRANSCH TOTALREFLECTOMETER for determining the index of refraction of substances by totalreflection.

7. LARGE SPECTROSCOPE for high dispersion and large field, used in recent color investigations of R. Gordon and W. Hallock.

8. READING TELESCOPE by Julius Grunow, with a focusing mechanism by separating the elements of the objective.

Nos. 5 to 8 are exhibited by the Department of Physics of Columbia College.

9. SIMPLEX SPECTROSCOPE, for simpler spectroscopic work. Exhibited by H. Cushman.

10. FIVE-ARC POTENTIOMETER, for comparison of electro-motive forces very accurately. Exhibited by H. Cushman.

11. Hand-Colored Lantern Slide of the solar spectrum. Exhibited by C. C. Trowbridge.

12. Set of Lantern Slides illustrating some physical phenomena. Exhibited by C. C. Trowbridge.

13. Air Pump with stopcocks automatically worked as valves. Exhibited by Prof. O. N. Rood.

14. Air Pump with stopcock worked by hand as a valve. Exhibited by Prof. O. N. Rood.

15. Apparatus for measuring resistances up to ten million million ohms. Exhibited by H. C. Parker.

16. Apparatus for measuring resistances as low as one millionth of an ohm. Exhibited by H. C. Parker.

17. Apparatus for analysis of sound by resonance, used in investigating the use of the mouth and nose cavities in articulating and singing; with photographs of voices. Exhibited by Dr. Floyd S. Muckey and Dr. W. Hallock.

18. Apparatus for comparing the rate of vibration of two tuning-forks by the photography of manometric flames; with negatives. Exhibited by Prof. W. Hallock.

19. Improved Key for certain electrical work. Exhibited by H. Cushman.

20. Seger's Pyramids. Test pieces of different mixtures of feldspar, clay, limestone, and quartz. Each of these test pieces has a different melting-point, thus forming a series which can be used in a furnace to record the temperature.

21. Siemens's Water Pyrometer. A copper vessel protected by felt, and containing a definite amount of water whose initial temperature is recorded by a thermometer. Into this water is plunged a copper or platinum cylinder of given weight and of the same temperature as the furnace into which it was previously placed. From the rise of temperature of the water, the temperature of the furnace is calculated.

22. Hobson's Pyrometer consists of a copper tube with wooden handle at one side, having a thermometer at the outer end and

an opening for the admission of cold air. By regulating the size of this opening, sufficient cold air lowers the temperature of the heated blast so that it can be read by means of the ordinary mercurial thermometer. By knowing the amount of dilution by cold air, the temperature of the heated blast can be approximated.

23. MESURÉ AND NOUEL'S OPTICAL PYROMETER. This pyrometer is based upon the refractive power of quartz for rays of light of different intensities. The angle of rotation is measured by two Nicols prisms, and serves as a measure of temperature.

24. LE CHATELIER AND CORNU'S PHOTOMETRIC PYROMETER consists of a photometer so arranged to compare the intensity of the luminous rays of light projected from a standard lamp flame with the rays of light issuing from the furnace or other heated object. The degree of adjustment of the aperture through which the furnace rays pass in order to equalize the intensities of the rays of light serves to measure the temperature.

25. LE CHATELIER'S THERMO-ELECTRIC PYROMETER consists of two wires, forming the thermo couple, which produces the electric current when introduced into a furnace or flame, the galvanometer, which measures the current produced; and the wires connecting both. The intensity of the current produced is resultant upon the temperature of the thermo couple in the furnace, and thus serves to measure it.

Nos. 20 to 25 are exhibited by J. Struthers.

26. HELIOSTAT. A modification of the Foucault form; made by the Geneva Optical Co. Exhibited by Dr. William Stratford.

27. MICROSCOPE STAGE. For photomicrography and measuring objects. Exhibited by Dr. William Stratford.

28. RULING MACHINE. Invented by Dr. Irvin Sickels. Rules on metal or glass, micrometers or gratings, 1 to 24,000 lines to the inch. Exhibited by Dr. William Stratford.

29. PANORAMA mounting of Rowland's photographs of the grating solar spectrum. Exhibited by W. Hallock.

DEPARTMENT OF ELECTRICITY.

In charge of Prof. F. B. Crocker.

30. Two Machines for producing alternating currents of various frequencies, for multiplex telegraphy and other purposes.

31. Electrometer for measuring low-voltage alternating currents.

32. Multicellular Electrostatic Voltmeter.

33. Speed Indicator operating by sound resonance.

34. Air-Condensers.

35. Unipolar Dynamo. A new type now being developed.

Nos. 30–35 exhibited by Prof. M. I. Pupin.

36. Model showing construction of latest type of armature for dynamos and motors.

37. Commutators of Electric Motors, showing peculiar effect of wear.

38. Standard International Ohm recently legalized in the United States and other countries.

39. Watt Meter for measuring the power of alternating and direct currents.

40. Electro-Dynamometers for measuring alternating and direct currents.

Nos. 36–40 exhibited by Prof. F. B. Crocker.

41. The Manufacture and application of disinfectants produced by electrolysis of salt water. Exhibited by A. E. Woolf.

42. Calcium Carbide, made in electric furnace and used to produce acetylene gas for illumination. Exhibited by E. N. Dickerson.

43. Apparatus for determining permeability of iron and steel. Exhibited by Max Osterberg.

DEPARTMENT OF ASTRONOMY.

In charge of Mr. Charles A. Post.

44. PHOTOGRAPHS OF STELLAR SPECTRA. Showing spectrum between F. and D.—that portion most easily observed by the eye. These plates are important as an evidence that photography is superior to the eye, even on its own ground. Exhibited by Prof. James E. Keeler, Allegheny Observatory.

44*a*. GLASS POSITIVES of Comets and of the Milky Way, made with 6-inch Willard Portrait lens of 31 inches focus. Exhibited by Prof. E. E. Barnard, of the Lick Observatory.

44*b*. PHOTOGRAPHS OF DRAWINGS OF MARS. By Percival Lowell, Lowell Observatory.

45. PHOTOGRAPHS OF LIGHTNING. Exhibited by Samuel W. Bridgham, M.E., President New York Camera Club.

46. PHOTOGRAPHS OF THE SUN DURING TRANSIT OF MERCURY, November 10, 1895. Showing an approximate method of determining the heliographic latitude and longitude of a point on the sun's disc. Exhibited by Charles A. Post, Strandhome Observatory.

47. IMPROVED FORM OF SMALL TELESPECTROSCOPE. By John A. Brashear. Exhibited by Charles A. Post.

There are exhibited by the Columbia College Observatory, J. K. Rees, Director, the following:

48. MEASURING (MICROMETER) MACHINE FOR ASTRONOMICAL PHOTOGRAPHS. By Repsold & Sons, of Hamburg.

49. REFLECTING CIRCLE, with stand and new form of Artificial Horizon. By Wanschaff, of Berlin.

50. SEVERAL PHOTOGRAPHS, made by the astronomers of the Lick Observatory, of the Moon, Sun's Corona, and Comets.

51. A LARGE POSITION MICROMETER of new design, by Saegmuller, of Washington.

52. A NEW EIGHT-INCH ASTRONOMICAL THEODOLITE, by Saegmuller.

35. A SMALL FOUR-INCH THEODOLITE, by Saegmuller.

54. A NEW INSTRUMENT to determine time, longitude, and latitude, by Saegmuller.

55. ENGINEERS' TRANSIT, with "solar," made of silver aluminum, by Saegmuller.

DEPARTMENT OF MECHANICS.

In charge of Prof. R. S. Woodward.

56. Model of INTERNATIONAL PROTOTYPE METRES.

57. Model of INTERNATIONAL PROTOTYPE KILOGRAMMES.

These Prototype Metres and Kilogrammes have been adopted as standards of length and mass, respectively, by nearly all nations. They were adopted as the official standards of the United States April 5, 1893.

58. AUTOMATIC MERCURY VACUUM PUMP. Designed by Professor Pupin.

59. Models of FORCING AND LIFTING PUMPS.

60. Model of BRAMAH'S HYDROSTATIC PRESS.

61. Two forms of GYROSCOPES.

62. HYPOCYCLOIDAL LINK.

63. PARALLEL LINK MOTION MACHINE.

64. Aggregation of different kinds of GEARING.

65. ELLIPTICAL GEARING.

66. IRREGULAR GEARING.

67. FERGUSON'S PARADOX.

68. "MULTIPLE GEARING."

DEPARTMENT OF EXPERIMENTAL PSYCHOLOGY.

In charge of Dr. Livingston Ferrand.

69. SPECIAL APPARATUS FOR THE DETERMINATION OF THE AFTER-IMAGE THRESHOLD. Designed by Mr. S. I. Franz, Columbia College. This apparatus is used to give stimuli of light, (a) of different intensities, (b) of different areas, and (c) of different lengths of exposure, to the eye of an observer.

70. GRAVITY CHRONOMETER. Used for measuring, by means of a falling screen, very small times of exposure of an object to the eye.

71. TACHISTOSCOPE. Designed by Dr. Harold Griffing, Columbia College. Constructed on the principle of the above-mentioned chronometer. The object of this instrument is to expose letters for a tenth of a second. Is being used in a special investigation of the accuracy of perception at different ages.

72. HARMONIUM. In which the intervals are not equal, but in which they stand in the relation to each other required by theory.

73. KYMOGRAPH. With electric motor attachment, of a very high rate of speed, with fixed drum and movable carriage.

DEPARTMENT OF PHYSIOLOGY.

In charge of Dr. John G. Curtis.

74. MODELS of the brain and other organs illustrating the use of inexpensive materials for purposes of physiological teaching. Exhibited by Prof. W. Gilman Thompson, M.D., of the Medical Department of the University of the City of New York.

75. KÜHNE'S SCHEMATIC EYE and accessories.

76. VON HELMHOLTZ'S working model of the ossicles of the human ear.

77. APPARATUS to illustrate a well-known optical delusion.

78. APPARATUS for the study of the contraction of muscle, as follows:

Ludwig's drum myograph.
Basel stand.
Moist chamber and muscle-forceps.
Tigerstedt's muscle-lever.
du Bois Reymond's induction coil.
du Bois Reymond's friction-key.
du Bois Reymond's mercurial key.
Pfeil's chronograph (2 specimens).

Electric tuning-fork of one hundred complete vibrations in one second.

Morse key.

Numbers 75 to 78, inclusive, exhibited by the Department of Physiology of Columbia College at the College of Physicians and Surgeons, New York.

DEPARTMENT OF BOTANY.

In charge of Dr. Carlton C. Curtis.

79. STUDIES IN THE GENUS RANUNCULUS. Prof. N. L. Britton. Exhibit of some of the rare and little known species, with an undescribed form from Virginia.

80. STUDIES IN AMERICAN BRYOLOGY. By Elizabeth G. Britton.
   1) A hybrid moss. The normal sporophyte and the hybrid occurring on the same plant of *Aphanorhegma serrata*. Exhibits: The specimens collected by Drummond, the slides under the microscope, and drawings made from these slides.
   2) *Physcomitrella patens*, its systematic position. Exhibits: Specimens, slides, and drawings are shown to prove that it has been wrongly placed among the cleistocarpous mosses, and that its natural alliance is with the Funariaceæ, to which it is closely related through its gametophyte.

81. STUDIES IN THE FLORA OF BOLIVIA. Prof. Henry H. Rusby, Exhibit of undescribed species from the Eastern Cordillera.

82. STUDIES OF THE NORTH AMERICAN LEGUMINOSÆ. Anna Murray Vail. Exhibit of undescribed and little known species.

82*a*. STUDIES OF THE NORTH AMERICAN SAXI FRAGACEÆ. Dr. Wm. E. Wheelock. Exhibit of little known species.

83. STUDY OF THE EAST AMERICAN SPECIES OF SANICULA. Eugene P. Bicknell. Exhibit of specimens and drawings illustrating the four recognized species, two of which are undescribed.

84. Study of the Flora of Central Florida. George V. Nash. Exhibit of species new to science.

85. Studies in the Botany of the Southeastern States. John K. Small. Exhibit of species new to science.

86. Study of the Lichens of Northeastern North America. Dr. Albert Schneider. Exhibit of microscopic preparations and drawings illustrating some of the more interesting genera.

87. Study of Stipules. A. A. Tyler. Exhibit of numerous species bearing these organs, with sketches showing their attachment.

88. New Japanese Characeæ. Dr. Timothy F. Allen. Exhibit of new and interesting species, with microscopic preparations of fruit and oospores.

89. Treatment of Delicate Tissues. Dr. Carlton C. Curtis.
   1) A simple dehydrating apparatus.
   2) A convenient mould for imbedding.
   3) An easily constructed settling tube.
   4) Trichomic development of *Primula*.

90. Formation of Pollen Grains. Dr. M. Rubino.
   1) Mother cell preparatory to division.
   2) Tetramerous stage of the mother cell.

91. Structure of Pollen Grains. Dr. Smith Ely Jelliffe.

92. Cuticularization of the Epidermal System. A. E. Anderson.
   1) Superficial cutinization in *Ageve*.
   2) Circular cutinization in *Abies*. Employing a modification of Gram's method.
   3) Formation of Stomata in *Sedum*, microscopic preparations and plates illustrating mechanism and structure.

93. Aleurone Grains. C. W. Ogden, Jr.
   1) Modification of grains in *Pæonia*.
   2) Component factors of grains in *Bertholletia*.

94. Vallisneria spiralis: Anatomy and Developmental History of Fruit, Seed, and Embryo. Effie A. Southworth.

95. ARACHIS HYPOGÆA: Anatomy and Physiology of the Gynophore. Anna S. Pettit.

96. STUDY OF THE VARIOUS SECRETORY ORGANS OF PLANTS OF THE FAMILY LEGUMINOSÆ. Bertha M. Dow.

97. COMPARATIVE STUDY OF THE PERIDEUM: The development in different species indicating the degree of relationship. Alexander Taylor.

99. MANNER OF GROWTH OF POROUS DUCTS OF THE GENUS *Rosa.* Agnes Pearson.

DEPARTMENT OF ANATOMY.

In charge of Prof. Geo. S. Huntington.

The series exhibited illustrates the development and the comparative morphology of the ileo-colic junction, cæcum and vermiform appendix, and the arrangement of the investing peritoneum. The peritoneal relations of the adult human cæcum and appendix present a number of variations, which are important factors in determining the position and arrangement of the structures. The peritoneal folds connecting the terminal ileum with the cæcum and appendix are usually fused with each other and with adjacent serous surfaces in the adult human subject and in the anthropoid apes in such a manner as to render their correct interpretation a difficult matter, which can only be properly elucidated by reference to the development of the parts, and by comparison with the similar structures in lower forms. The details and results of a research based in part on the preparations exhibited are given in a publication entitled "Studies in the Development of the Alimentary Canal. I. Cæcum and Vermiform Appendix." New York, 1894. Report of Embryologist, Society of the New York Lying-in-Hospital.

100. I. ILEO-COLIC JUNCTION IN FISHES, AMPHIBIA, AND REPTILES.

In *Fishes* there is rarely a separation between the small and large intestine. The entire canal is short, provided in some forms (Sharks) with a spiral valve for the purpose of retarding the movement of contents. The Sturgeon (Acipenser Sturio) presents a differentiation between large and small intestine, marked by a valve resembling the pylorus.

In *Amphibia* the alimentary canal is simple, without cæcum, and usually short.

Among *Reptiles* only the Land-turtles, some Ophidia, and some Saurians, like Lacerta, Iguana, Polychros, Draco, Chameleo, Seps, Scincus, possess a cæcum.

Nos. 1–13.

1 Salmo fontinalis, Brook Trout. Alimentary Tract.
2 Rana catesbiana, Bull Frog. Alimentary Tract.
3 Boa constrictor, Black Boa. Intestine.
4 Boa constrictor, Black Boa. Intestine opened, showing spiral valve in interior.
5 Chrysemys picta, Mud Turtle. Alimentary Tract.
6 Alligator mississippiensis, Alligator. Alimentary Tract.
7 Alligator mississippiensis, Alligator. Alimentary Tract.
8 Alligator mississippiensis, Alligator. Alimentary Tract.
9 Alligator mississippiensis, Alligator. Ileo-colon.
10 Iguana tuberculata, Iguana. Ileo-colon.
11 Iguana tuberculata, Iguana. Ileo-colon.
12 Iguana tuberculata, Iguana. Ileo-colon.
13 Iguana tuberculata, Iguana. Ileo-colon.

101. II. Ileo-Colic Junction in Birds.

In *Birds* the length of the intestine varies very much. It is short in species living on fruits and insects, long in those feeding on seeds, plants, and fish. Peculiar to Birds are the double cæca which are usually found. In the Passerine Birds, living on seeds and insects, the cæcal pouches are commonly short and rudimentary, as they are also in some of the piscivorous divers, Alca, Larus, and Pelargus. They are very long in the Ostrich, in Rhea, Apteryx, and the Lamellirostra, who feed chiefly on plants. Some carnivorous birds, as Corvus, Strix, etc., have fairly long cæca, although as a rule carnivorous forms have short pouches, whereas they are long in herbivorous birds. In some (Ostrich) the cæca contain a spiral valve.

In place of the usual double pouch a single cæcum is at times found, as in Cicinia and Ardea. In some forms the small intestine presents also a cæcal appendage, the remains of the vitelline duct (Urinator). This condition is also at times observed in man, constituting the so-called Diverticulum of Meckel.

(Nos. 14–21).

14 Casuarius casuarius, Cassowary. Ileo-colon and cæcal pouches.

15 Casuarius casuarius, Cassowary. Ileo-colon and cæcal pouches.

16 Dromaius novæ-hollandiæ, Emu. Ileo-colon and cæcal pouches.

17 Bubo virginianus, Great-horned Owl. Ileo-colon and cæcal pouches.

18 Bubo virginianus, Great-horned Owl. Ileo-colon and cæcal pouches.

19 Urinator lumme, Red-shouldered Loon. Ileo-colon and cæcal pouches.

20 Urinator lumme, Red-shouldered Loon. Small intestine with normal cæcal pouch, the remains of vitelline duct.

21 Human, adult. Small intestine presents a Meckel's diverticulum, the remains of the vitelline duct, normally obliterated completely in Mammals.

102. III. Ileo-Colic Junction, Cæcum and Vermiform Appendix in Mammals.

The mammalian alimentary tract usually presents a cæcum in some form. Exceptions to this rule:

The orders Insectivora and Chiroptera, in which the absence of a cæcum is characteristic. (No. 93.)

There are also isolated instances of the lack of this structure in other orders, notably in several Cetaceans, Physeter macrocephalus, Delphinus delphis, Monodon monoceros, Phocæna communis. (No. 49.)

Further in some carnivorous Marsupials (Dasyurus), in the single instance of Myoxus among Rodents, in certain Edentates, Tardigrada, and Manidæ, and in the carnivorous group of the Arctoidea.

Nos. 28–32, 35, 36, 74–87.

Didelphia.

Marsupalia.

Cæcum large in the Didelphidæ, Opossums (Nos. 22–25), and Macropodidæ, Kangaroos (Nos. 26, 27).
Absent in Dasyuridæ.
Provided with a vermiform appendix in the Wombat, Phascolomys ursinus.

22 Didelphis virginiana, Opossum. Ileo-cæcum.
23 Didelphis virginiana, Opossum. Ileo-cæcum.
24 Didelphis virginiana, Opossum. Ileo-cæcum.
25 Didelphis sp.? Banana Opossum. Ileo-cæcum.
26 Halmaturus derbyanus, Rock Kangaroo. Ileo-cæcum.
27 Halmaturus derbyanus, Rock Kangaroo. Ileo-cæcum.

Monodelphia.

Edentata.

A. Phytophaga, or Vegetable Feeders. Tardigrada.

Cæcum absent.

28 Cholœpus didactylus, Two-toed Sloth. Ileo-colon.
28*a* Cholœpus didactylus, Two-toed Sloth. Ileo-colon.

B. Entomophaga, or Insect Feeders.

1. Mutica.

28*c* Myrmecophaga didactyla, Two-toed Ant-Eater. Two cæcal pouches.
29 Myrmecophaga jubata, Great Ant-Eater. Ileo-colon; cæcum absent.
30 Myrmecophaga jubata, Great Ant-Eater. Ileo-colon; cæcum absent.
31 Myrmecophaga jubata, Great Ant-Eater. Ileo-colon; cæcum absent.

2. Squamata.

32 Manis longicauda, Long-tailed Pangolin. Ileo-colon; cæcum absent.

3. Loricata.

Dasypodidæ, Armadillos.

Dasypus. Lateral colic cæca (Nos. 33, 34).
Tolypeutes. No colic cæca.
Xenurus. No colic cæca.
Chlamydophorus. Lateral colic cæca.
Tatusia. No colic cæca (Nos. 35, 36).

33 Dasypus sexcinctus, 6-banded Armadillo.
34 Dasypus sexcinctus, 6-banded Armadillo.
35 Tatusia novemcincta, 9-banded Armadillo.
36 Tatusia novemcincta, 9-banded Armadillo.

Non Deciduata.

Ungulata.

Intestine very generally provided with a large cæcum.

Perissodactyla.

1. Equidæ, Horses. Cæcum very large.
2. Rhinocerotidæ, Rhinoceros. Cæcum very large.
3. Tapiridæ, Tapirs. Cæcum large, with rudimentary appendix; colon looped.

37 Tapirus americanus, Tapir. Ileo-cæcum.
38 Tapirus americanus, Tapir. Ileo-cæcum.
39 Tapirus americanus, Tapir. Ileo-cæcum.

Artiodactyla.

A. Non-Ruminantia.

1. Suidæ, Hogs. Cæcum present (Nos. 40, 41).
2. Hippopotamidæ, Hippopotamus. Cæcum absent.

40 Sus scrofa, Fœtal Pig. Ileo-cæcum in situ.
41 Dicotyles torquatus, Collared Peccary. Ileo-cæcum.

B. Ruminantia.

Cæcum large; colon spirally coiled.

42 Auchenia glama, Llama. Ileo-cæcum and colon.
43 Bos indicus, Zebu, neonat. Ileo-cæcum and colon.
43a Bos indicus, Zebu, neonat. Ileo-cæcum and colon.

43*b* Bos indicus, Zebu, neonat. Ileo-cæcum and colon.
44 Capra hircus, var. angorensis, Angora Goat. Ileo-cæcum and colon.
45 Boselaphus tragocamelus, Nilghai. Ileo-cæcum and colon.
46 Capra œgagrus, Bezoar Goat. Ileo-cæcum and colon.

Sirenia.

Cæcum short, bifid.

47 Manatus americanus, Manatee. Ileo-cæcum.
48 Manatus americanus, Manatee. Ileo-cæcum.

Cetacea.

Cæcum absent in several. Physeter, Delphinus, Monodon, Phocæna.

49 Phocæna communis, Common Porpoise. No demarcation between large and small intestine.

Deciduata.

A. Zonaria.

Hyracoidea.

Hyrax; Intestine presents three cæca, one in the ordinary position, and two others much lower down on the colon—opposite one another, terminating by pointed ends.

Proboscidea.

Cæcum very large.

50 Elephas indicus, Indian Elephant. Ileo-cæcum, anterior surface.
51 Elephas indicus, Indian Elephant. Ileo-cæcum, lateral surface.
52 Elephas indicus, Indian Elephant. Ileo-cæcum, posterior surface.

Carnivora.

A. Pinnipedia.

Cæcum small.

53 Phoca vitulina, Harbor Seal. Ileo-cæcum.
54 Phoca vitulina, Harbor Seal. Ileo-cæcum.

55 | Phoca vitulina, Harbor Seal. Ileo-cæcum.
56 | Phoca vitulina, Harbor Seal. Ileo-cæcum.
57 | Otaria gillespiei, Gillespie's Sea Lion. Ileo-cæcum.

B. Fissipedia.

The *Cynoidea*, including dogs, jackals, foxes, and wolves, form a well marked central group, with highly developed convoluted cæca, placed laterally to the intestinal lumen (Nos. 58–63).

From this type depart on the one hand the *Ailuroidea*, including civets and cats, with cæcum uniformly present, but short and markedly pointed, suggesting the degeneration of a formerly more developed structure (Nos. 64–73), while on the other the *Arctoidea*, including bears, weasles, and raccoons, constitute a group bound together by many common fundamental peculiarities of structure, among which is the complete absence of a cæcal appendage to the intestinal tract (Nos. 74–87).

Among the *Ailuroidea*, Hyæna occupies an isolated position in reference to the cæcum, possessing a well-marked pouch, with blunt extremity, resembling the structure in Didelphis (No. 73).

CYNOIDEA.

58 | Canis familiaris, Dog. Ileo-cæcum.
59 | Canis familiaris, Dog. Ileo-cæcum.
60 | Canis familiaris, Dog, fœtal. Ileo-cæcum in situ.
61 | Vulpes fulvus, Gray Fox. Ileo-cæcum.
62 | Vulpes fulvus, Gray Fox. Ileo-cæcum.
63 | Vulpes fulvus, Gray Fox. Ileo-cæcum.

AILUROIDEA.

64 | Felis domesticus, Common Cat. Ileo-cæcum.
65 | Felis domesticus, Common Cat. Ileo-cæcum.
66 | Felis domesticus, Common Cat. Ileo-cæcum.
67 | Felis borealis, Canada Lynx. Ileo-cæcum.
68 | Felis concolor, Puma. Ileo-cæcum.
69 | Herpestes griseus, Ichneumon. Ileo-cæcum.
70 | Herpestes sp. ? Ileo-cæcum.
71 | Paradoxurus typus, Paradoxure. Ileo-cæcum.
72 | Paradoxurus trivirgatus, 3-striped Paradoxure. Ileo-cæcum.
73 | Hyæna striata, Striped Hyæna. Ileo-cæcum.

Arctoidea.

74 Ursus americanus, Black Bear. Ileo-colon.
75 Ursus americanus, Black Bear. Ileo-colon.
76 Ursus arctos, Brown Bear. Ileo-colon.
77 Ursus maritimus, Polar Bear. Ileo-colon.
78 Ursus maritimus, Polar Bear. Ileo-colon.
79 Procyon lotor, Racoon. Ileo-colon.
80 Procyon lotor, Racoon. Ileo-colon.
81 Nasua rufa, Coati. Ileo-colon.
82 Nasua rufa, Coati. Ileo-colon.
83 Taxidea americana, Badger. Ileo-colon.
84 Cercoleptes caudivolvulus, Kinkajou. Ileo-colon.
85 Bassaris astuta, Racoon-fox. Ileo-colon.
86 Bassaris astuta, Racoon-fox. Ileo-colon.
87 Bassaris astuta, Racoon-fox. Ileo-colon.

B. Discoïdea.

Rodentia.

With the exception of one group, the Doormice, Myoxinæ, all Rodents have a large cæcum, presenting in some forms (Lepus) an appendage.

Nos. 88–92.

88 Hystrix cristata, European Porcupine. Ileo-cæcum.
89 Erethizon dorsatus, Canada Porcupine. Ileo-cæcum.
90 Dasyprocta aguti, Agouti. Ileo-cæcum.
91 Sciurus hudsonicus, Red Squirrel. Ileo-cæcum.
92 Arvicola pennsylvanicus, Meadow Mouse. Ileo-cæcum.

Insectivora.

Cæcum absent.

Cheiroptera.

Cæcum absent.

93 Pteropus medius, Fruit Bat. Ileo-colon.

Primates.

Cæcum present. Vermiform appendix in Nycticebus, Gorilla, Chimpanzee, Orang, Gibbou, and Man.

Simiadæ.

1. *Arctopithecini—Marmosets.*

Cæcum long, curved, uncinate, and somewhat diminished at distal end.

94 Midas ursulus, Negro Tamarin. Ileo-cæcum.
95 Midas geoffroyi, Geoffroy's Marmoset. Ileo-cæcum.
96 Hapale jacchus, Common Marmoset. Ileo-cæcum.
97 Hapale œdipus, Marmoset. Ileo-cæcum.
98 Harpale sp.? Marmoset.? Ileo-cæcum.

2. *Platyrrhini—New-World Monkeys.*

Cæcum long, curved, somewhat pointed at distal extremity.

99 Ateles geoffroyi, Black-handed Spider Monkey. Ileo-cæcum.
100 Ateles ater, Black-faced Coaita. Ileo-cæcum.
101 Ateles ater, Black-faced Coaita. Ileo-cæcum.
102 Ateles sp.? Ileo-cæcum.
103 Ateles sp.? Ileo-cæcum.
104 Pithecia satanas, Black Saki Monkey. Ileo-cæcum.
105 Pithecia satanas, Black Saki Monkey. Ileo-cæcum.
106 Mycetes fuscus, Brown Howler Monkey. Ileo-cæcum.
107 Nyctipithecus commersonii, Vitœ Monkey. Ileo-cæcum.

Cebidæ.

Cæcum lateral to lumen of intestine, as in Cynoidea, at times presenting a tendency to convolution.

108 Cebus leucophæus, Cebus Monkey. Ileo-cæcum.
109 Cebus monachus, Cebus Monkey. Ileo-cæcum.
110 Cebus capucinus, Capuchin Monkey. Ileo-cæcum.
111 Cebus capucinus, Capuchin Monkey. Ileo-cæcum.
112 Cebus capucinus, Capuchin Monkey. Ileo-cæcum.
113 Cebus capucinus, Capuchin Monkey. Ileo-cæcum.
114 Cebus niger, Black Cebus Monkey. Ileo-cæcum.
115 Cebus hypoleucus, White-throated Sapajou. Ileo-cæcum.
116 Cebus hypoleucus, White-throated Sapajou. Ileo-cæcum.
117 Cebus apella, Apella Monkey. Ileo-cæcum.
118 Cebus leucocephalus, White-headed Cebus. Ileo-cæcum.

119 Cebus flavescens, Pale Cebus. Ileo-cæcum.
120 Cebus sp.? Ileo-cæcum.
121 Cebus sp.? Ileo-cæcum.

3. Catarrhini.—Old World Monkeys.

a. Cynomorpha.

Cæcum usually large, short, blunt-pointed.

122 Macacus rhesus, Rhesus Monkey. Ileo-cæcum.
123 Macacus pileatus, Capped Macaque. Ileo-cæcum.
124 Macacus pileatus, Capped Macaque. Ileo-cæcum.
125 Macacus pileatus, Capped Macaque. Ileo-cæcum.
126 Macacus nemestrinus, Bruh Monkey. Ileo-cæcum.
127 Macacus ochreatus, Ashy-black Macaque. Ileo-cæcum.
128 Macacus cynomolgus, Kra Monkey. Ileo-cæcum.
129 Macacus cynomolgus, Kra Monkey. Ileo-cæcum.
130 Mycacus sinicus, Bonnet Macaque. Ileo-cæcum.
131 Cynocephalus hamadryas, Arabian Baboon. Ileo-cæcum.
132 Cynocephalus hamadryas, Arabian Baboon. Ileo-cæcum.
133 Cynocephalus sphinx, Papion. Ileo-cæcum.
134 Cynocephalus sphinx, Papion. Ileo-cæcum.
135 Cynocephalus sphinx, Papion. Ileo-cæcum.
136 Cynocephalus babouin, Yellow Baboon. Ileo-cæcum.
137 Cynocephalus porcarius, Chacma Baboon. Ileo-cæcum.
138 Cynocephalus porcarius, Chacma Baboon. Ileo-cæcum.
139 Cynocephalus porcarius, Chacma Baboon. Ileo-cæcum.
140 Cercopithecus callitrichus, Green Monkey. Ileo-cæcum.
141 Cercopithecus pogonias, Bearded Monkey. Ileo-cæcum.

b. Anthropomorpha.

Cæcum large, provided with a vermiform appendix.

142 Simia satyrus, Orang. Ileo-cæcum.
143 Simia satyrus, Orang. Ileo-cæcum.
144 Simia satyrus, Orang. Ileo-cæcum.
145 Troglodytes niger, Chimpanzee. Ileo-cæcum.
146 Troglodytes niger, Chimpanzee. Ileo-cæcum.
147 Troglodytes niger, Chimpanzee. Ileo-cæcum.
148 Troglodytes niger, Chimpanzee. Ileo-cæcum.

Anthropidæ.

Human fœtal cæcum and appendix.
Nos. 149–162.

Human infantile cæcum and appendix.
Nos. 163–167.

Human juvenile cæcum and appendix.
Nos. 168–170.

Human adult cæcum and appendix.
Nos. 171–193.

Human adult cæcum, absence of appendix.
No. 194.

DEPARTMENT OF ZOÖLOGY.

In charge of Prof. J. A. Allen.

Modern Taxidermy. Illustrated by Specimens from the American Museum of Natural History.

It is only within the last few years that taxidermy, at least in America, could rightly claim rank as an art. Its recent great improvement in methods and results is largely due to the establishment of departments of taxidermy in our leading museums, enabling the artist-taxidermist to give full scope to his abilities. The specimens shown illustrate the former and present grades of work.

103. The CHIMPANZEE "CHICO" *(Anthropopithecus troglodytes)*, mounted by Mr. J. Rowley, Jr., January, 1895, at the American Museum of Natural History. This example beautifully illustrates the possibilities of the newer taxidermy.

104. Another CHIMPANZEE, showing the better grade of commercial work of ten years ago. To be compared with the preceding.

105. TURKEY *(Meleagris gallopavo)*, showing the modelling of the head and wattles by recent methods.

106. Another TURKEY, illustrating average museum work of ten years ago.

107. PIGEONS, to show treatment of wattles by the newer methods.

108. YOUNG FOXES. Recent work.

New Species and Subspecies of American Mammals. From American Museum of Natural History.

109. ARIZONA JACK RABBIT (*Lepus alleni*, Mearns), the largest and most beautiful Hare known. From Fairbank, Arizona.

110. DESERT KANGAROO RAT (*Dipodomys deserti*, Stephens).

111. KANGAROO RAT (*Dipodomys spectabilis*, Merriam). From Cochise County, Arizona.

112. TEXAS POCKET MOUSE (*Perognathus merriami*, Allen). From Brownsville, Texas.

113. TRINIDAD POCKET MOUSE (*Heteromy sanomalus*). From the island of Trinidad.

114. ROUND-TAILED MUSKRAT (*Neofiber alleni*, True). A connecting link between the common Meadow Mice and the Muskrat.

115. *Nectomys palmipes*, Allen and Chapman. A web-footed WATER RAT, from the island of Trinidad.

116. Two species of PLANTAIN MICE (*Oryzomys velutinus*, Allen and Chapman, and *O. brevicauda*, Allen and Chapman). From the island of Trinidad.

117. BLACK-BACKED MOUSE (*Evotomys fuscodorsalis*, Allen). From New Brunswick.

Mammals from the Black Hills Region, South Dakota, showing Influence of Environment. From American Museum of Natural History.

118. WOOD RATS from the wooded Black Hills and from the adjoining plains to the eastward (*Neotoma grangeri*, Allen, and *N. rupicola*, Allen).

119. GROUND SQUIRRELS, from the wooded Black Hills and the adjoining plains to the eastward (*Tamias quadrivittatus borealis*, Allen, and *T. minimus*).

120. WHITE-FOOTED MICE, from the Black Hills *(Sitomys americanus arcticus)* and the adjoining plains to the eastward *(S. a. nebracensis.)*

121. Specimens of the VARYING HARE *(Lepus americanus)*, showing seasonal change of color by moulting. (See *Bull. Am. Mus. Nat. Hist.*, vi., 1894, pp. 107–128.)

Miscellaneous. From American Museum of Natural History.

122. MURINE OPOSSUM *(Didelphys murina)* and young, from the island of Trinidad. Among the smaller species of Opossum are some in which the female has the external abdominal pouch but slightly developed, while in others it is entirely wanting. The young, however, as in the fully pouched species, are born at a very early stage, and are at once transferred to the nipples of the parent, to which they remain attached until fully developed.

123. A series of MOTMOTS *(Momotus cæruleiceps)*, showing stages in the mutilation of the tails. The Motmots, of which some eighteen species are found in tropical America, are remarkable among birds for their habit of trimming their central tail-feathers.

124. A mounted specimen of the QUEZAL OR PARADISE TROGON *(Pharomacrourus paradiseus)*, showing the effect of continued exposure to the light.

125. A SKIN of the same species, which has been preserved in a cabinet.

126. Specimens of the eastern and western HIGH-HOLES OR FLICKERS *(Calaptes auratus* and *C. cafer)*. Showing typical examples of both species and hybrids between the two. Where the boundaries of the ranges occupied by these two species adjoin, they apparently hybridize. (See *Bull. Am. Mus. Nat. Hist.*, vol. iv., 1892, pp. 21–44.)

127. Specimens of the SAME SPECIES illustrating the variations in the marking of a single feather. (See *Bull. Am. Mus. Nat. Hist.*, vol. iii., 1891, pp. 311–313.)

128. EGGS, and a series of EMBRYOS of the LOGGERHEAD TURTLE *(Thalassochelys cavetta)*, showing stages of growth for every five days during the period of development in the egg. The Loggerhead Turtle of our South Atlantic coast reaches a weight of five hundred pounds. Its eggs are laid during the summer on the sea beach in a hole dug by the Turtle. Some one hundred and fifty eggs are deposited. They hatch at the end of the sixtieth day, and the young Turtles at once make their way to the sea. The specimens shown were collected by Mrs. F. E. B. Latham, at Micco, Florida.

Insects. From American Museum of Natural History.

129. A collection of ORTHOPTERA found within fifty miles of New York City. (See *Bull. Am. Mus. Nat. Hist.*, vol. vi., 1894, pp. 249–316.)

130. TWO MOUNTED HUDSONIAN GODWIT *(Limosa hæmastica)*. Adult and young. Illustrating discovery of the voluntary opening of the extremity of the bill. C. C. Trowbridge (Department of Physics, Columbia College.)

Exhibit of Brain and Spinal Cord Cells Stained by the Golgi Chrome-Silver Methods.

O. S. Strong (Biological Department, Columbia College).

131. CORTEX OF HUMAN CEREBELLUM. A section of the human cerebellum, showing: (1) the outer or molecular layer; (2) the row of Purkinje cells, with the coarser of their protoplasmic processes extending towards the periphery; (3) the granular layer; and (4) the innermost layer of fibres. This preparation, made by Dr. Piersol and kindly loaned by Dr. Van Gieson, is stained with carminate of soda and shows about all the details that can be shown without the aid of the Golgi preparations.

132*a*. PURKINJE CELLS OF THE ADULT HUMAN CEREBELLUM. Preparation showing the protoplasmic processes filling the outer or molecular layer of a sulcus of the adult human cerebellum.

132*b*. NEUROGLIA OR "SPIDER" CELLS OF INNER LAYERS OF HUMAN CEREBELLUM. The heavy black branching processes shown here and in other preparations are capillaries which are also impregnated. Adult human brain. By Strong's "formalin-bichromate modification."

133. PURKINJE CELL OF THE ADULT HUMAN CEREBELLUM. Highly magnified portion of the protoplasmic processes of a Purkinje cell, showing their fine granular lateral processes. Prepared by Strong's "formalin-bichromate modification" of the Golgi method.

134. BASKET NETWORK OF NERVE FIBRES AROUND PURKINJE CELLS—HUMAN CEREBELLUM. The so-called "baskets" in the cerebellum. Fibres running in the molecular layer parallel to the surface send processes at right angles inwards, whose terminations cluster around the bodies of the Purkinje cells, forming the "baskets." Prepared by means of Strong's "formalin-bichromate modification."

135*a*. BASKET NETWORK AROUND PURKINJE CELLS. Individual "basket" fibres, showing the right-angled processes above mentioned.

135*b*. NEUROGLIA CELLS IN ADULT HUMAN CEREBELLUM. The neuroglia elements in the molecular layer of the adult human cerebellum. They are the parallel vertical fibres, and are processes of cells whose bodies occupy the same layer as that in which are the bodies of the Purkinje cells. In No. 132 we had only the protoplasmic processes of the Purkinje cells appearing in the molecular layer, while here in one place only or principally the basket fibres and in another place only the glia elements appear. Yet all co-exist side by side in the same cerebellar layer. Formalin-bichromate modification.

136. PYRAMID NERVE CELLS IN CEREBRAL CORTEX OF AN EIGHT-MONTHS' HUMAN EMBRYO; showing principal protoplasmic process proceeding towards the periphery of the brain, accessory protoplasmic processes, and the axis cylinder process proceeding in the opposite direction from the principal protoplasmic process. Prepared by the "rapid Golgi method."

137. PYRAMID CELLS. Vertical section through the cerebral cortex (anterior calcarine) of an eight-months' human embryo. Rapid Golgi.

138. Pyramid Cells in the Cerebrum of Tadpole. Prepared by the "rapid Golgi method."

139. Spinal Ganglion Nerve Cells of a Chick, seventh day of incubation. They are seen to be in the primitive bipolar condition, each with one process entering the spinal cord (on the right), and the other proceeding in the opposite direction towards the periphery. Prepared by the "rapid Golgi method."

140. Spinal Cord Fibres of a Chick. Horizontal section through the same cord, showing the bifurcation of the posterior root fibres as they enter the cord. They appear like very wide Y's. By the "rapid Golgi method."

141. Spinal Cord Cells of a Chick. Transverse section through the same cord, showing some of the ependyma cells lining the central canal and sending long processes through the cord to its periphery. Also showing their cilia projecting into the central canal. By the "rapid Golgi method."

142. Spinal Cord Cells of an Embryo Pig. Prepared by means of the "mixed Golgi method."

143. Corpus Dentatum, section through the. Showing the arrangement of its nerve cells and fibres. Eight-months' human embryo. Rapid Golgi.

144. Axis-Cylinders. Showing their varicosities. Cerebellum of an eight-months' human embryo. Rapid Golgi.

145. Nerve Cells in the Optic Thalamus. Eight-months' human embryo. Rapid Golgi.

The preparations are accompanied by explanatory photographs or drawings. The photographs (some of which are kindly loaned by Dr. M. Allen Starr) were taken by Dr. Edward Leaming, who will also show transparencies of the same.

Exhibition of Embryological Specimens.

By Bashford Dean (Biological Department, Columbia College).

146. Embryonic Development of the Gar-pike *(Lepidosteus osseus)*. A series of specimens of embryonic and larval stages obtained at Black Lake, St. Lawrence Co., N. Y.

This ganoid is a surviving representative of a race of palæozoic fishes, from which all living fishes (except the sharks and lung fishes) are descended. There are reasons on the side of palæontology for believing that this ganoidean group is derived from the line of the ancient sharks ; it is now of especial interest that the study of the earlier stages of the gar-pike which this valuable, and in fact unique material represents, tends to confirm this view. The eggs were fertilized artificially.

147. ADULT GAR-PIKE.

148. Zeigler models illustrating the EARLY DEVELOPMENT OF SHARKS, illustrated by three models.

By Dr. William Stratford (College of the City of New York).

149. EGG-CASE OF THE PORT JACKSON SHARK, *Cestracion galeatus*. From Southern Australia.

150. YOUNG OF THE DUCK-BILL, *Ornithorhynchus platypus*. From Queensland.

By Henry E. Crampton (Biological Department, Columbia College).

151. EMBRYONIC DEVELOPMENT OF SNAILS (*Physa* and *Limnæa*), showing that the right or left spiral coils of the shell are predetermined by the first stages of cell division of the embryo.

The adult shell of *Physa* is spirally wound to the *left*. The adult shell of *Limnæa*, on the other hand, is spirally wound to the *right*. It is interesting to observe that these peculiarities of the adult shells are foreshadowed in the earliest cleavage stages of the embryo. In *Physa*, for example, the first group of micromeres are budded off to the *left ;* in *Limnæa*, to the *right*.

152. EIGHT-CELL STAGE OF PHYSA, showing the budding off to the *left* of the first group of micromeres.

153. EIGHT-CELL STAGE OF LIMNÆA, showing the budding off of the first group of micromeres to the *right*.

154. TWELVE-CELL STAGE OF PHYSA, showing the budding off of the second group of micromeres to the right.

155. TWELVE-CELL STAGE OF LIMNÆA, showing the budding off of second group of micromeres to the *left*.

(N. B. The 1st and 2d groups of micromeres are always given off alternately to *right* or *left*, or vice versa.)

Exhibit of Cytological Preparations.

156–160. CHROMATIN AND ARCHOPLASM DURING FERTILIZATION, or union of the male and female hereditary elements, in eggs of the sea-urchin. Four stages: Magnified 1000 diameters. Stained by " iron hæmatoxylin method."

By Edm. B. Wilson (Biological Department, Columbia College).

This exhibit shows that the dynamic cell-dividing *Archoplasm* substance is entirely derived from the male cell or spermatzoön.

156*a*. EGG OF SEA-URCHIN BEFORE FERTILIZATION. Section of ovarian egg of sea-urchin (Toxopneustes) showing the nucleus or germinal vesicle (the large clear vesicle) and the nucleolus or germinal spot (the round black body within the vesicle). With accompanying photograph magnified 1000 diameters.

156*b*. FERTILIZATION OF SEA-URCHIN EGG. Egg of Toxopneustes, more highly magnified, showing the process of fertilization. The sperm nucleus (which has penetrated into the egg from the outside) appears as a small, black, conical body. Beside it is the star-shaped sperm-aster or archoplasm. The egg nucleus now appears as a small rounded vesicle. With accompanying photograph magnified 1000 diameters.

156*c*. EGG OF SEA URCHIN PREPARING TO DIVIDE INTO TWO CELLS. Egg of Toxopneustes preparing for first division or cleavage, showing the "amphiaster," each half of which will pass into one of the daughter-cells. With photograph 1000 diameters.

156*d*. CELL DIVISION OR SEGMENTATION INTO 16 CELLS. Segmenting of egg of Toxopneustes (16 cell-stage) in section showing the cleavage-amphiasters. With photograph 1000 diameters.

161. A series of PHOTOGRAPHS (each enlarged 1000 diameters) of sections of other stages in the fertilization of same eggs. Prepared by Dr. Edward Leaming.

162. A series of LANTERN SLIDES from the same negatives. (Dr. Leaming.)

163–168. CHROMATIN OR HEREDITARY SUBSTANCE. Mode of equal distribution to all the cells of the body. From the lobster. Iron hæmatoxylin stain.

By A. L. Kean (Biological Department, Columbia College).

Demonstration of five successive stages in the process of indirect division (karyokinesis), as seen in developing spermatic cells of the lobster.

163. RESTING STAGE. A resting cell showing the quiescent nucleus. The chromatin (stained black) is in unequal masses and distributed throughout the nucleus. The nuclear membrane is distinct.

164. SKEIN STAGE. The first phase of activity of the cell preparatory to division. The nucleus shows the formation of minute threads connecting the chromatin elements. This is the so-called "skein stage."

165. CHROMOSOME (CHROMATIN RODS) AND CENTROSOMES. A cell nucleus in full karyokinesis. The chromatin has become arranged into regular bodies (chromosomes) in a central spindle plate (equatorial plate). Fine fibres run outwards from the chromosomes and are focussed in *centrosomes* at the two *poles* of the spindles. The cell is now ready for division. The chromosomes will divide first and pass towards the spindle poles.

166. DIVISION OF CHROMOSOMES (CHROMATIN RODS)—SPINDLE STAGE. A cell showing the first stage of division. The chromosomes have divided and appear as two parallel bands in the centre of the spindle (see below 12).

167. DIVISION—MIDDLE STAGE. A cell showing the later stages of division. The spindle fibres are disappearing and the cell itself is beginning to divide.

168. DIVISION—FINAL STAGE. The final stage in cell division is

shown in the same field as above (No. 10). Two daughter-cells are seen lying side by side. The line of division is still perceptible.

Gary N. Calkins (Biological Department, Columbia College).

169. DEMONSTRATION OF BUTSCHLI'S ARTIFICIAL PROTOPLASM. For some years Professor Butschli, of Heidelberg, has been studying the structure of living protoplasm. This he describes as a "Schaumplasma," or froth protoplasm, and compares it to certain structures in soap-suds, oil emulsions, etc. Upon experiment he found that he could make an emulsion which, under high magnification, closely resembles in structure and in motion living protoplasm. This mixture consists of olive oil and potassium carbonate. Under proper conditions of temperature the emulsion shows streaming motion almost identical with the motion of Amoeba protoplasm.

170. A CILIATE INFUSORIAN (STYLONYCHIA) DURING NUCLEAR DIVISION. The preparation shows the interchange of micronuclei. This phenomenon was first observed by Stein for Stylonychia in 1861. Stylonychia has two micronuclei in different parts of the cell body, and when these divide the halves exchange places and thus the daughter-cells possess portions of each of the original micronuclei. Two of these halves are seen passing each other.

171. A FLAGELLATE INFUSORIAN WITH A DISTRIBUTED NUCLEUS. This organism was formerly considered a non-nucleated form and was supposed to belong to the group called *Monera* by Haeckel. A similar distributed nucleus is found in many bacteria.

172. SUPPOSED YOLK FORMATION IN THE DEVELOPING EGG OF THE EARTHWORM *(Lumbricus terrestris)*. This shows that the chromatic elements of the nucleus are the source of yolk substance in the egg. The large black mass (the yolk nucleus) outside the nuclear membrane is derived from the chromatin. Minute fibres may be seen passing outwards from the yolk nucleus into the cell. These fibres break up into granules and become distributed throughout the cell, where they enlarge and form yolk substance.

DEPARTMENT OF PALÆONTOLOGY.

In charge of Prof. Henry Fairfield Osborn.

Exhibit by J. J. Stevenson (University of the City of New York, Department of Geology).

173. EURYPTERUS.

174. By Gilbert van Ingen and W. D. Matthew (Department of Geology, Columbia College).

The Middle Cambrian fossils exhibited are from Div. I *c* and I *d*. The fauna is a trilobite fauna, with the genera: *Paradoxides*, *Agnostus*, *Microdiscus*, *Conocoryphe*, *Ptychoparia*. There are also Brachiopods: *Protorthis*, *Acrothele*, *Lingulella*, *Linnarssonia;* Gastropods: *Paleacmea;* Pteropods: *Hyolithes;* Cystid plates: *Eocystites;* Sponge spicules: *Protospongia*.

These fossils are from the lowest rocks of the geological scale and represent the earliest forms of life, which have been found in a fossil state, upon the earth.

II. LOWER AND MIDDLE CAMBRIAN FOSSILS, from St. John, N. B.

The section of St. John basin is as here:

Stages		*Age*	*Fauna*
Div. III.	*e* *d*	Ordovician	True Graptolites
	c *b* *a*	Upper Cambrian	Rooted Graptolites—Dictyonema
Div. II.	*c* *b* *a*		No fauna
Div. I.	*d* *c*	Middle Cambrian	Paradoxides
	b *a*	Lower Cambrian	Protolenus

The Lower Cambrian fossils exhibited are specimens of a trilobite, *Protolenus* from Div. I *b*, the lowest faunal zone of the St. John series. A considerable fauna was collected from this zone. It is now being studied by Mr. G. F. Matthew and will form the subject of a future communication to the Academy.

III. GRAPTOLITES OF THE GENUS DICTYONEMA, from the Upper Cambrian of St. John, N. B. *Dictyonema*, a funnel-shaped graptolite colony attached to the ocean bottom by a stem and roots. The smaller of the two large slabs holds three perfect specimens. The beds of papyraceous shale of Div. III *c*. Navy Island, St. John Harbor, are replete with these organisms. A future communication to the Academy by Mr. G. F. Matthew will contain new information regarding these and associated fossils. (See Exhibit II.)

Exhibited by T. G. White (Department of Geology, Columbia College).

IV. ORDOVICIAN FOSSILS, from the shores of Lake Champlain. Suite of specimens from the Ordovician series of the Lake Champlain valley. Exhibited by Theodore G. White, Ph.B. The preliminary paper on the field-work in two townships, Essex and Willsboro, was read before the Academy last May, and published in the *Proceedings*, vol. xiii., pp. 214–231. The study is now being continued to embrace the stratigraphy and fossils of the Ordovician rocks throughout the Champlain valley and their extension into Canada. The Terranes here represented are:

UTICA: Trilobites and Graptolites.

TRENTON: An abundant representation of Brachiopods, Trilobites, Gasteropods, Cephalopods, Lamellibranchs, Corals, Crinoids, and plant remains.

CHAZY: Several distinct sets of beds. Several large Gasteropods (*Maclurea*) and Cephalopods; also Brachiopods and Hydroid-Corals (*Solenopora*).

CALCIFEROUS: *Ophileta uniangulata* and plant remains.

· By Arthur Hollick (Department of Geology, Columbia College).

175. New Species of CRETACEOUS (Dakota Group) LEAVES, from the West. Two of the species (*Liriophyllum populoides* Lesq. and *Liriodendron alatum* Newb.) have wing-like appendages to the petioles, first described in *Bull. Torr. Bot. Club*, Nov., 1894, which apparently represent the beginnings of what we now know as stipular appendages to the leaves.

176. New Species of CRETACEOUS (Laramie Group) LEAVES, mostly from Colorado, now being studied for description in connection with a forthcoming *Bulletin of the U. S. Geol. Survey.*

177. Specimens of CRETACEOUS LEAVES AND MOLLUSCS from Martha's Vineyard, part collected personally, the remainder, recently sent for identification from the U. S. Geol. Survey. These latter represent the best portion of the material collected by Mr. David White, described in *Am. Journ. Sci.*, xxxix. (1890), 93–101, which first demonstrated conclusively the existence of cretaceous strata at Gay Head.

By Department of Vertebrate Palæontology, American Museum of Natural History. Exhibit arranged by Henry F. Osborn, Curator, and J. L. Wortman, in charge of field expeditions.

This department was established in 1891, and explorations have since been actively carried on in the Rocky Mountain region, principally in New Mexico, Utah, Wyoming, and Dakota, resulting in the discovery of a large number of rare types.

178. EVOLUTION OF THE HORNS OF THE TITANOTHERES. This represents four stages in the evolution of the horns in animals of a remarkable group which lived in North America during the Eocene and lower Miocene periods. Specimen *a* shows the skull of *Palæosyops*, a middle Eocene ancestral form without horns; *b*, skull of *Telmatotherium validum*, shows the very first suggestions of the appearance of a horn at the point indicated by the white arrow; *c*, skull of *Telmatotherium cornutum* (upper Eocene), shows the incipient horn clearly marked, also indicated by white arrow; *d*, skull of *Titanotherium coloradense* (lower Miocene), shows short but well developed horns; and *e*,

skull of *Titanotherium bucco*, exhibits the horns in their extreme forms of development, taking up the whole anterior portion of the skull.

179. THE ANCESTRAL FOUR-TOED HORSE AND THE MODERN HORSE. Placed side by side are skeletons of the diminutive *Hyracotherium venticolum*, or four-toed horse, $3\frac{1}{3}$ hands high, and the skeleton of a recent horse, *Equus caballus*, $15\frac{1}{2}$ hands, belonging to the modern trotting breed. The interval in time which separates these types is roughly estimated at two million years. The former skeleton is unique; it comes from near the base of the Eocene, and was found by Dr. Wortman, in 1883. It belongs to the famous Cope Collection which has been recently acquired by the American Museum of Natural History. This is publicly exhibited for the first time.

180. EVOLUTION OF THE SKULL OF THE HORSE. This series of skulls, probably the most complete which has ever been brought together, shows the changes which have transformed the diminutive skull of *Hyracotherium venticolum*, or four-toed horse, into that of the living horse.

181. EVOLUTION OF THE FOOT OF THE HORSE. This series of feet is parallel to that of the skulls, and shows the changes through which the feet have passed from *Hyracotherium venticolum* to *Equus caballus*. These changes, which are fully explained upon the labels, consist mainly in the enlargement of the median toe and the reduction and disappearance of the lateral toes.

182. SKULLS OF AMERICAN FOSSIL RHINOCEROSES. The first remains of the Rhinoceroses in America were announced by Leidy in 1859. Since then the explorations of Cope have brought to light two new forms, and the expeditions of the American Museum have procured three new forms, representing probably the complete series of Lower Miocene Rhinoceroses. They are observed to increase gradually in size, in the complication of the grinding teeth, and in the loss of the canine and lateral pair of incisors. The last member of the series is an ancestor of the two-horned Rhinoceroses which appear in the Middle Miocene. *a. Aceratherium trigonodum.* This is the

smallest and oldest type which has thus far been discovered. It exhibits a canine tooth. *b. Aceratherium mite.* This is a slightly larger type, in which the canine has disappeared. *c. Aceratherium occidentale.* This is a considerably larger type, in which the lateral incisors are becoming reduced. Probably has four toes. *d. Aceratherium tridactylum.* This is a form represented by a complete skeleton in the Museum. Has only three toes. *e. Aceratherium platycephalum.* This is a flat-headed Rhinoceros of very large size, and remotely related to the other forms. *f. Diceratherium dakotense.* This is apparently an ancestor of the line of Diceratherium or Rhinoceroses with horns placed side by side.

183. RESTORATION OF THE SKELETON OF AGRIOCHOERUS. This is a very remarkable animal, the characters of which have only just been made known by the explorations of the American Museum and of Princeton College. The skull and dentition is like that of a herbivore, but the toes are clawed somewhat as in the carnivores. The restoration was under the direction of J. L. Wortman.

DEPARTMENT OF GEOLOGY.

In charge of Prof. J. J. Stevenson.

184. Collection of ORES AND COUNTRY ROCKS, from the Sudbury Nickel Mines, Ontario. Collected (1894) and exhibited by J. F. Kemp and T. G. White. The ore bodies at Sudbury consist of nickeliferous pyrrhotite and of chalcopyrite, in dark diorites of Huronian age. They are on the outer portions of the intrusions of igneous rock and near the walls, which are granite, quartzite, etc. The ores are roasted and smelted to mattes and afterwards refined. The raw ores, the roasted ores, and the mattes are all illustrated. The district is now the chief source of nickel.

(Twenty specimens.)

185. Collection of ORES AND COUNTRY ROCK AND PHOTOGRAPHS, from the Gap Nickel Mine in Lancaster Co., Pa. Collected

(1894) and exhibited by J. F. Kemp. The geology and mineralogy are practically the same as at Sudbury, Ont. The Gap Mine began to produce nickel about 1862, and for twenty years was the principal nickel mine of the world.

(Ten specimens.)

186. Collection of ORES, COUNTRY ROCK, AND PHOTOGRAPHS, from the Mesabi Iron Range, of Minnesota. Collected (1894) and exhibited by J. F. Kemp and T. G. White. The Mesabi ores have almost revolutionized iron mining on Lake Superior. Enormous bodies of soft but rich ore lie under a cap of gravel and in cherts and quartzites. The photographs exhibit the methods of mining with steam shovels.

(Twenty-five specimens.)

187. Collection of PRE-CAMBRIAN VOLCANIC ROCKS, from various points on the Atlantic seaboard, including St. John, N. B., Mt. Desert and Mt. Kineo, Me., Marblehead and Quincy, Mass., the South Mountain, Pa., and Southwest Virginia. Collected and exhibited by W. D. Matthew, T. G. White, and J. F. Kemp. It is now known that just before the opening of the Cambrian period, volcanic action was widespread along the Atlantic seaboard. The old acidic lavas, tuffs, etc., have been usually called felsites, but they have been found to possess, in greater or less perfection, all the characteristic structures of recent lavas. The New Brunswick and Mt. Desert collections are to be described before the Academy.

(Thirty specimens.)

188. SLABS OF FOSSILIFEROUS SHALE, SHOWING THE EFFECTS OF LATERAL COMPRESSION. Upper Devonian, Ithaca, N. Y. Collected and exhibited by Gilbert van Ingen. The slabs are marked with north and south lines. The force which distorted the fossils was applied in an approximately north and south direction, which is perpendicular to the axes of the anticlinal and synclinal folds that cross the lake region of Central New York. The evidence suggests that the distortion of the fossils and the formation of the folds were produced by the same force acting at the same time. Exhibited by Gilbert van Ingen.

189. Specimens of the GRANITE INTRUSION at Harrison, Westchester Co., N. Y. Collected and exhibited by Heinrich Ries. A great intrusion of granite has penetrated the mica schists and has had a gneissoid structure induced in it by dynamic metamorphism. (Described before the Academy Feb. 18, 1895.)

190. Series of TOPOGRAPHICAL MAPS of portions of New York State so far as yet issued by the State Engineer, in co-operation with the U. S. Geological Survey. Exhibited by J. F. Kemp.

191. Specimens of GABBRO AND RELATED ROCKS, from an outlying area of the Cortland series, near Croton Falls, on the Harlem R. R., N. Y. Collected and exhibited by Heinrich Ries, To be described before the Academy in the spring of 1895. The eastern limits of the igneous area, best developed in the town of Cortland, near Peekskill, have never been well worked out. This discovery proves them to extend in outliers over into the Harlem valley.

192. Specimens of PRE-CAMBRIAN ROCKS, from Blue Wing, Granville Co., North Carolina, showing the copper ore and associated rocks of that region. Collected and exhibited by J. J. Stevenson.

(Twenty-seven specimens.)

These slates are termed Huronian by Prof. W. C. Kerr, and lie between two areas of Laurentian. Within Granville and Person counties they show many veins carrying ores of copper, but the concentration is rarely sufficient to make mining profitable. The ores are chalcocite, bornite, chrysocolla, and occasionally malachite and azurite.

193. Specimens of LAVAS from the Sandwich Islands. Collected by C. H. Hitchcock and exhibited by J. J. Stevenson.

(Fourteen specimens.)

194. A series showing the occurrence of REDONDITE and its associated rocks. Collected by C. H. Hitchcock and exhibited by J. J. Stevenson.

(Ten specimens.)

Redonda is a volcanic island belonging to the Leeward group, and is but one mile long by one fourth of a mile wide. It was covered with guano, which has been removed. A phosphatic mineral, Redondite, has been discovered in the rocks, filling crevices and encrusting fragments. Some of the "bunches" measure forty feet in each direction. The origin is somewhat uncertain, but the material may have been derived from the leaching of the guano. The lava is of Quaterary age and volcanic activity is still shown in several of the Leeward islands.

DEPARTMENT OF MINERALOGY.

In charge of L. P. Gratacap.

195. Suite of PYROXENES from New York State. These minerals are found in the igneous rocks and in the contact zones between these rocks and the limestones into which they have been intruded. The types shown are Augites from Warwick, Mineville, Keene, Diana, and Monroe; Diopsides from Russell, De Kalk, Tilly Foster, Pt. Henry, Pitcairn, Cascadeville, and Sing Sing. To be described in vol. xiv., *Trans. N. Y. Ac. Sci.*

196. ARTIFICIAL ZINC OXIDE, massive and crystals. This forms on roof of furnaces used in manufacture of zinc oxide. The smaller crystals show good faces. Described in *Amer. Jour. Sci.*, Sept., 1894.

197. TOURMALINE from Tilly Foster iron mines, Putnam Co., N. Y.

198. APPARATUS FOR OBTAINING SECTIONS OF ANY DESIRED ORIENTATION. By means of this apparatus it is possible to obtain on first trial a section showing the interference figure.

199. Group of SLAG-CRYSTALS from iron furnaces at Cornwall, Pa.

Nos. 195–199 exhibited by Heinrich Ries.

200. ROSOLITE. A new ornamental stone composed of Rose Garnet (Grossularite), Vesuvianite (yellow), and Wollastonite (white), Silicates of Alumina and Lime. It occurs in a volcanic region, and has been produced by the metamorphosis of sedimentary rocks. Its industrial use is at once apparent. Found at Xalostoc, Mexico, which is the only deposit in the world.

201. PHOTOGRAPHS of Rosolite Quarry, Xalostoc, Mexico.

202. GADOLINITE (basic ortho silicate of yttrium, beryllium, and iron). The largest crystal of this rare mineral ever found. Dimensions, 11 in. x 6 in. Weight, 18½ lbs. Found at Barringer Hill, Llano Co., Texas.

203. YTTRIALITE (silicate of yttrium and thorium). Barringer Hill, Llano Co., Texas.

204. THOROGUMMITE (a hydrous silico-uranate of thorium). Barringer Hill, Llano Co., Texas.

205. NIVENITE (a hydrated uranium-thorium-yttrium-lead uranate). Barringer Hill, Llano Co., Texas.

Note.—From the three last named minerals thoria is extracted, the principal element in the manufacture of the Welsbach lamp.

Nos. 200–205 exhibited by William Niven.

206. QUARTZ CRYSTAL showing the tetartohedral form of the pyramid of the second order, the trigonal pyramid. Crystal Peak, Colorado.

207. QUARTZ CRYSTAL. Example of fine etching. Lincoln Co., North Carolina.

208. QUARTZ CRYSTAL. Amethystine, highly modified. From a new locality in Lincoln Co., North Carolina.

209. QUARTZ CRYSTAL. Of cubic aspect; the plus rhombohedron predominating and the minus rhombohedron and the prism being greatly reduced. San Miguel Co., New Mexico.

210. RHODOCHROASITE AND RHODOCHROSITE GEM. Clima, Colorado.

211. MICROCLINE. A group of nine basal twins. Crystal Peak, Colorado.

Nos. 206–211 exhibited by Lazard Cohn.

212. OPAL. Two examples of opal infiltrations in a jasperoid ironstone. Baricoo, New Zealand. These opal films occur in a concretionary ferruginous sandstone or jasper, and have been formed by the deposition of opal silica through the crevices of the enclosing ironstone.

213. OPAL. A curious example from the same locality (Baricoo, New Zealand), in which the reticulating cracks in the ironstone are filled in with opal.

214. RUTILATED QUARTZ *(Sagenite).* The crystals of rutile (clove-brown) penetrating transparent quartz are unusually dense. The quartz is a water-worn boulder. Madagascar.

215. RUTILATED QUARTZ *(Sagenite).* In this example the rutile crystals are cinnamon-colored. Madagascar.

216. DIAMOND CRYSTAL. Elongated hexoctahedron; brilliant yellow. From near King's Mt., North Carolina. Weight, $\frac{7}{8}$ karat.

217. DIAMOND CRYSTAL. Curved and elongated hexoctahedron; greenish-yellow. From the glacial drift at Waukesha, Wisconsin. Weight, $15\frac{21}{32}$ karat. The largest American diamond known.

218. DIAMOND CRYSTAL. Hexoctahedron; white. From glacial drift at Oregon, Dane Co., Wisconsin. Weight, $3\frac{3}{4}$ karat.

219. Model of DIAMOND CRYSTAL. Original found, in 1894, at Drogiac, Michigan, in glacial drift. Weight, $10\frac{7}{8}$ karat.

Note.—These three diamonds were unmistakably found in glacial drift deposits, and hence were evidently derived from some deposits, veins, or pockets situated in the north.

220. EMERALD. Stony Point, Alexander Co., North Carolina. This remarkable crystal is one of the largest emerald crystals in the world. (See Gems of North America).
Nos. 212–220 are exhibited by George F. Kunz.

221. A series of BABYLONIAN AND ASSYRIAN CYLINDERS, SEALS, etc., illustrating mineralogical material used for these purposes in 4000 to 300 B.C. From the collection of Tiffany & Co. and that of the Rev. W. Hayes Ward.

222. Set of one hundred and seventy sections illustrating the OPTICAL PROPERTIES OF MINERALS and their usual appearance in rocks. This set has been prepared for use in the new undergraduate course in Optical Mineralogy.

223. HAND SECTION CUTTER, for cutting small crystals at definite angles.

Rare or New Species.

224. KALLILITE, Ni Bi S, from Siegen, Prussia.

225. VESZELYITE, from Banat, Hungary. Phospho-arsenate of copper and zinc.

226. SELLARTE, $Mg\ F_2$. Gebroulaz, Savoy.

227. VOLTAITE, an iron sulphate from Schmöllnitz, Hungary.

228. GLAUCOPHANE, Syra, Greece. Original locality.

229. NICKEL ALUMINA SILICATE. Buncombe Co., N. C.

Specimens from New Localities.

230. VARISCITE, $Al\ Po_4 + 2H_2O$, from Utah County, Utah, in nodules.

231. TETRADYMITE, Bi_2Te_3, from Helena, Montana.

232. BISMUTHMITE, Bi_2S_3, from Jefferson Co., Montana.

233. HEMATITE CRYSTALS. Zacatecas, Mexico.

234. MENACCANITE CRYSTAL. North Garden, Virginia.

235. CUPRITE RHOMBIC DODECAHEDRON, from Anaconda Mine.

236. MONAZITE CRYSTAL, from South Lyme, Conn.

237. ATACAMITE CRYSTALS, from Globe Mines, Arizona.

238. MASSICOT, PbO, from near Tombstone, Arizona.

239. MINIUM, Pb_3O_4, from Tombstone, Arizona.

240. BROCHANTITE, from Zacatecas, Mexico.

241. ALLANITE, large specimen, Mineville, N. Y.

Other Specimens.

242. Casts of CAVITIES in Quartz of Upper Montclair, N. J. The original mineral is unknown.

243. CHALCOPYRITE in tabular crystals, possibly pseudomorphic after Marcasite, from Bruce Mine, Lake Huron.

244. SERPENTINE "Cubic Pseudomorph, after an unknown mineral."

245. Azurite Crystals. Bisbee, Arizona.

246. Ferriferous Cuprite. Bisbee, Arizona.

247. Phantom Quartz. Japan.

248. Zincite Pyramid $\frac{3}{4}$, from Franklin, N. J.

249. Tourmaline Twin, from Franklin, N. J.

250. Vesuvianite Crystals embedded in Garnet, from Piedmont.

Exhibit of W. D. Matthews.

251. Carborundum Suite consisting of *(a)* Carborundum as it comes from the furnace, blue variety. *(b)* Same, green variety. *(c)* Amorphous variety, formed at lower temperature. *(d)* Graphite, a by-product. *(e)* Grinding wheel of Carborundum. *(f)* Whetstone of Carborundum.

Nos. 222–251 exhibited by Mineralogical Department, School of Mines, Columbia College, through Alfred J. Moses.

252. Large Phantom Calcite. Joplin, Mo.

253. Phantom Calcites, from Burnet, Texas.

254. Quartz Group, from Butte, Mont.

255. Fossil Specular Iron Ore, from Cherry Valley, Mo.

256. Cluster of Sphalerite Crystals, with implanted crystals of Chalcopyrite. Joplin, Mo.

257. One Large Hanksite. Borax Lake, Cal.

Nos. 252–257 exhibited by Frank L. Nason:

258. Group of Halite Crystals. Borax Lake, Cal.

259. Thenardite Crystals. Borax Lake, Cal.

Nos. 258, 259 exhibited by Department of Geology, American Museum Natural History.

260. Native Lead. Langban, Sweden.

261. Sulphur. Cianciana, Sicily.

262. Malybdenite. Aldfield township, Pontiac Co., Quebec, Canada.

A suite illustrating crystallization and occurrence.

263. CALOMEL. Avala, Servia. Crystallized.

264. PYRITE. Miners' Delight Mine, Tooele Co., Utah. Cubes in Kaolin.

265. CUPRITE. Copper Queen Mine, Bisbee, Arizona. The finest specimen found in America.

266. MARTITE. Twin Peaks, Millard Co., Utah.

267. DIASPORE. Chester, Mass. Crystallized.

268. QUARTZ. Hot Springs, Ark. A suite selected from the famous Lawrence Collection; showing phantoms formed by included minerals, penetrations, rare forms, etc.

269. RHODONITE var. PAISBERGITE. Paigsberg, Sweden.

270. SPODUMENE. Huntington, Mass. Large crystal.

271. BERYL var. EMERALD. Crab Tree, Mt. Mitchell Co., N. C. A new locality.

272. EPIDOTE, gray. Huntington, Mass.

273. TOURMALINE, brown. Hamburg, N. J.

274. TOPAZ, in gaugue. Juab Co., Utah. A recent find.

275. LEADHILLITE. Beercellar Mine, Granby, Mo. Recently obtained at this localty by Dr. Foote.

276. CALCITE. Granby, Mo. Amethystine with Marcasite "phantom."

277. CALCITE var. MEXICAN ONYX. Pueblo, Mexico. Brecciated.

278. SMITHSONITE. Kelly, N. M. New locality.

279. BASTASITE on TYSONITE. Manitou Springs, Col.

280. PHOSGENITE. Monte Poni, Sardinia.

281. REMINGTONTE. Santa Rosalia Mines, Boleo, Mexican California.

282. AZONITE on WAD. Copper Queen Mine, Bisbee, Arizona.

283. CASWELLTE. Franklin, N. J.

284. COLEMANITE. Borax Lake, San Bernardino Co., Cal.

Rare new species from the Santa Rosalia Mines, Boleo, Mexican California.

285. BOLËITE, BOUGLISITE, CUMENGËITE, and SPHÆROCOBALTITE. A full suite illustrating varied habits of crystallization and associated minerals.

Nos. 260–285 exhibited by Dr. A. E. Foote, Philadelphia, Pa.

DEPARTMENT OF BACTERIOLOGY.

In charge of Dr. T. M. Cheesman.

(Bacterial Laboratory, Department of Pathology, College of Physicians and Surgeons, Columbia College.)

Some of the characters of the bacteria, illustrated by their growth on nutrient gelatin (a), nutrient agar (b), nutrient broth (c), and on potato (d).

Specimens preserved in formalin.

286. BACILLUS SUBTILIS (hay bacillus) a b c d

287. " MESENTERICUS VULGATUS (potato bacillus). a b c d

288. VIBRIO PROTEUS a b c d

289. MICROCOCCUS FRIERÉ (once claimed as the cause of yellow fever). a b c d

290. BACILLUS PRODIGIOSUS a b c d
(This bacillus was the cause of the so-called miracle of the "bloody host," from its growth upon the wafer or altar-bread after its exposure in the church, during the consecration of the host.)

291. " MINIACEUS (found in water). a b c d

292. " MAGENTA (found in water). a b c d

293. Bacillus rubrum—plymouth— a b c d
(found in water).

294. " fluorescens liquefaciens a b c d
(very abundant in many waters).

295. " fluorescens a b c d
(abundant in water).

296. Micrococcus agilis a b c
(found in water, one of the few motile cocci).

297. Sarcina aurantica a b c d
(abundant in the air).

298. " lutea a b c d
(abundant in the air).

299. Spirillum rubrum a b c

300. Staphylococcus pyogenes aureus a b c d
(pyogenic).

301. " epidermidis albus a b c d
(abundant in the skin, sometimes pyogenic).

302. Streptococcus pyogenes a b c
(pyogenic).

303. Actinomyces a b c
(cause of the disease known as actinomycosis, or "lumpy jaw" in cattle).

304. Bacillus pyocyaneus α a b c d
(cause of the occasional green color of pus).

305. " tuberculosis glycerin agar culture.
(cause of tuberculosis in man and animals)

306. " anthracis a b c d
(cause of a disease variously known, according to the method of infection, etc., as anthrax, malignant pustule, wool-sorter's disease, and splenic fever. This was the first bacterium that was proven to have a causative relation to disease in man or animals).

307. " mallei (morve) a b c d
(cause of glanders in man and animals).

308. BACILLUS TETANI b —grows only in an atmosphere deprived of oxygen ; chemical absorption of the oxygen by pyrogallol, Buchner's method
(cause of tetanus or "lock-jaw").

309. " ŒDEMATIS MALIGNI a —grows only in an atmosphere deprived of oxygen ; mechanical exclusion of air by a layer of oil
(cause of malignant œdema).

310. " DIPHTHERIÆ a b c
(cause of diphtheria).

311. DIPHTHERIA TOXIN, resulting from the growth of the B. diphtheriæ in broth. Used to inoculate horses and other animals to induce artificial immunity.

312. DIPHTHERIA ANTITOXIN ; serum from the blood of a horse, rendered highly immune by repeated inoculations with the diphtheria toxins. Used hypodermically in the treatment of diphtheria as a curative agent, and also as a protective agent to those who have been exposed to infection.

313. DIFFERENTIAL CULTURES OF TWO BACILLI, one pathogenic, the other not pathogenic under normal conditions, which are frequently associated and which in many respects resemble one another so closely that they may be confounded.

	Bacillus typhosus (cause of typhoid fever)	Bacterium coli commune (abundant in the large intestine)
Gelatin	inconstant differences	
Agar	do do	
Broth	usually no pellicle formed.	usually pellicle is formed
Lactose—litmus agar	turns blue, or no change in color	change in color, turns red
Fermentation test	no gas formed	gas is formed
Potato	spreading, invisible growth	abundant yellow growth
Milk	not coagulated	is coagulated
Nitrates	not reduced	are reduced
Indol	not formed	is formed

314. CHART, showing the determinations used for identification of bacteria.

All the preparations in this department are exhibited by Dr. T. M. Cheesman.

DEPARTMENT OF PHOTOGRAPHY.

In charge of Dr. Edward Leaming.

315. *a)* LARGE PHOTOMICROGRAPHIC APPARATUS of Messrs. Carl Zeiss of Jena with appurtenances.

b) FRAMES containing some recent results in photographic process work, from European firms. From Chemical Museum, School of Mines, Columbia College.

316. *a)* VERTICAL PHOTOMICROGRAPHIC APPARATUS of E. Leitz, Wetzlar.

b) PROJECTION APPARATUS, after Edinger, as arranged for photography by E. Leitz, Wetzlar. From Wm. Kraft, New York.

317. STEREO-PHOTOCHROMOSCOPE—"An instrument which, with almost equal simplicity, does for color what the phonograph does for sound." Frederic E. Ives, Philadelphia.

318. KINETOSCOPE, after Edison. From Wallace & Alexander, New York.

319. *a)* DOUBLE LANTERN, with dissolving keys, pressure gauge, and automatic pressure regulator.

b) DOUBLE HIGH-PRESSURE DISSOLVING KEY.

c) ELECTRIC ARC PROJECTING LAMP AND LANTERN, with variable resistance coil and frame. Stand for the same. From Chas. Beseler, New York.

320. LANTERNS AND APPARATUS, exhibited by Messrs. J. B. Colt & Co.

a) LANTERNS WITH OIL LIGHT.
b) TRIPLE OXY-HYDROGEN STEREOPTICON.
c) ELECTRIC DOUBLE STEREOPTICON.
d) ELECTRIC LANTERN AND MICROSCOPE, for Photomicrography.
e) HIGH-PRESSURE DISSOLVING KEY.

321. *a)* HAND PRESS, in operation, showing method of printing photogravure plates.

b) FRAMES, containing photogravures, photogelatines, plain and in colors. From Photogravure Co., New York.

322. REPRODUCTIONS from paintings and engravings, and photographs from life, printed in carbon on porcelain, Japanese tissue paper, Whatman's drawing paper, and other surfaces. From James L. Breese, The Carbon Studio, New York.

a) ARTOTYPE (gelatine) reproductions in monochrome and colors, of paintings, book bindings, rugs, and ancient books and documents.

b) FAC-SIMILE DAGUERROTYPE of the first photograph ever taken of the living human face. The original daguerrotype was taken about 1840 by Dr. Draper in New York, the subject being the Doctor's sister; it is now in the possession of Herschel in England. This frame also contains a gelatine print copy of the original daguerrotype, and a recent photograph, silver print, of the same lady. The daguerrotype and gelatine print were made when the original was on exhibition at the Columbian Exposition. From Edw. Bierstadt, New York.

323. EXAMPLES OF HALFTONE WORK, plain and in colors and in halftone photo-lithography. From Photochrome Co., New York.

324. A special adaptation of an ordinary TELESCOPE LENS FOR PHOTOGRAPHY, with a diagram showing the relative positions of the flint and crown glasses for either visual or photographic work. Exhibited by Henry S. Curtis.

325. A series of PHOTOGRAPHS illustrating the tele-photic effects obtained with the above lens, compared with pictures of the same scenes taken with an ordinary photographic lens of about five inches focus. Exhibited by Henry S. Curtis.

326. Impressions of ANTIQUE GEMS AND SEALS in a special wax compounded by Prof. O. N. Rood; together with enlarged photographs of the same by Prof. W. Hallock.

327. *a)* LANTERN SLIDES, showing recent results in cytophotography, from preparations by Prof. Edmund Wilson, Ph.D., Dep. Biol. Col. Coll. × 1000 diameters, and reduced.

b) LANTERN SLIDES, showing recent results in the photomicrography of the central nervous system, from preparations after methods of Golgi, Cajal, Strong, and others, by O. S. Strong, Biol. Lab. Col. Coll. × 195 diameters, and reduced.

c) LANTERN SLIDES, showing recent results in photomicrography of Bacteria, from preparations by T. M. Cheesman, M.D., Bacteriological Lab. Coll. Phys. and Sur. 1000 diameters. From Photographic Lab. Dept. Path., Coll. Phys. and Sur. Col. Coll., New York.

328. LANTERN SLIDES of flowers, colored by hand. From C. Van Brunt.

329. A TRIPLE LANTERN IN OPERATION, showing the projection in three primary colors of lantern slides so combined as to produce the effect on the screen of a picture in natural colors. R. D. Gray, New York.

330. DEVICE to facilitate focusing with the fine adjustment of the microscope in photomicrography. From F. D. Skeel, M.D., New York.

331. PANORAMIC CAMERA. From Scovill & Adams, New York.

NEW YORK ACADEMY OF SCIENCES.

Late LYCEUM OF NATURAL HISTORY.

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