BROCHURE 2 OF VOL. II. PAGES 113-200.

PROCEEDINGS

OF THE

ROCHESTER ACADEMY OF SCIENCE

VOLUME II.

EDITED BY
ARTHUR LATHAM BAKER, *Secretary*.

ROCHESTER, N. Y.
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CONTENTS OF BROCHURE 2 OF VOL. II.

SCIENTIFIC PROCEEDINGS.

Papers read 1892-1893, but not printed:

The PRESIDENT now introduced PROFESSOR W. R. DUDLEY of Cornell University, who gave the second lecture of the Popular Lecture Course on

THE GEOGRAPHICAL DISTRIBUTION OF THE APPALACHIAN FLORA.

The lecture was illustrated by lantern views.

MARCH 14, 1892.

BUSINESS MEETING.

The President, PROFESSOR H. L. FAIRCHILD in the chair.

Thirty persons present.

The COUNCIL report recommended :

(1.) The election of MR. HOWARD L. OSGOOD as an active member.

(2) The payment of certain bills.

The candidate was elected by formal ballot and the bills were ordered paid.

PROFESSOR ARTHUR L. BAKER read a paper entitled :

NON-EUCLIDEAN GEOMETRY.

The paper was illustrated by black-board diagrams and demonstrations.

The discussion was participated in by PROFESSOR AREY, MR. J. E. PUTNAM, the PRESIDENT and others.

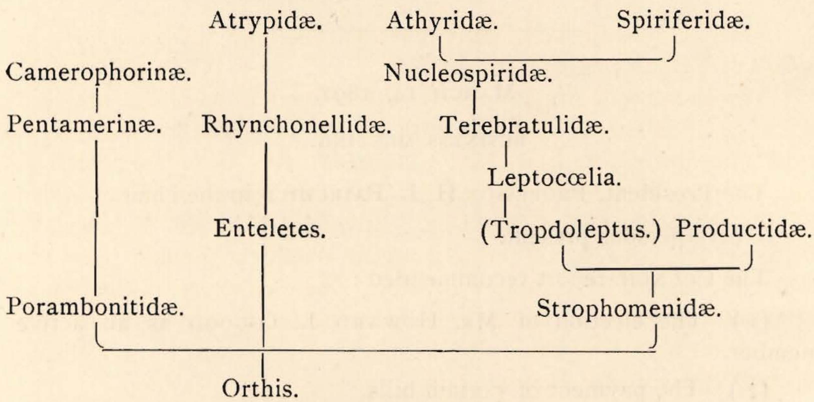
In the absence of the author, PROFESSOR A. L. AREY read the following paper :

ON THE BRACHIAL APPARATUS OF HINGED BRACHIOPODA AND ON THEIR PHYLOGENY.

BY H. S. WILLIAMS.

A serious difficulty met with in attempting to make a natural classification of Brachiopoda, has arisen from the uncertainty or ignorance as to the true relationship between the calcified loop of the Terebratulidæ and spiral processes of the Helicopegmata.

In the Report on the Salt Range Fossils of India, (Mem. Geol. Surv., India, Series XIII, Productive lime-stone fossils, IV, fasc. 3., pp. 549–550, Calcutta, 1884), Waagen proposed the following arrangement of the Hinged-Brachiopoda (Arthropomata) as an expression of his idea of the affinities of the various families :



In this classification it will be seen that Waagen makes the Athyridæ and Spiriferidæ, through the Nucleospiridæ to be the successors or descendants of the Terebratulidæ.

Davidson, commenting upon a letter from Waagen, communicating the above classification, (Mon. Brit. Foss. Brachiopoda, Vol. V. pp. 389–390) remarked :

"The subject will, however, demand much further consideration, for the passage between the loop-bearing Terebratulidæ and the spiral-bearing Spiriferidæ has not yet been discovered." This remark of Davidson was published in the last month of 1884, and I have been unable to find that any one since then has been able to throw light upon the difficulty involved.

The following suggestions will, I think, point to the nature of the modifications by which these two important groups of Brachiopods were differentiated.

In attempting to explain the relationship of the several families of Brachiopods in a course of lectures on the History of Organisms, (delivered at Cornell University, this particular lecture, on Feb. 16, 1892,) I found it necessary to explain why the fleshy spiral arms of the Terebratulidæ coil in a reversed direction from those of the calcified spiral supports in the Spiriferidæ.

In studying out this problem the following facts were observed :

According to the latest reported range of genera of Terebratulacæ, given by Davidson, (Lc. p. 353), the following genera have been found in the Silurian :

Waldheimia, *Centronella* Billings, *Renessellæria* and *Leptocalia* Hall.

This includes the sub-family *Centronellinæ* and the genus *Waldheimia* of the sub-family *Terebratulidæ*.

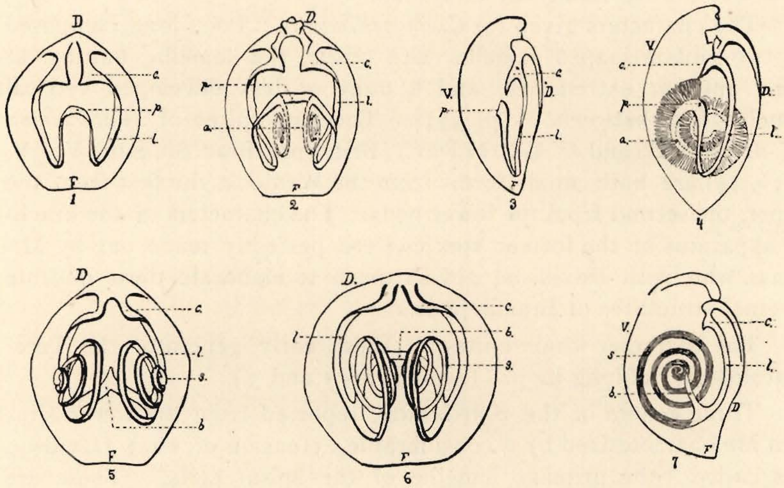
The characters given for *Centronellinæ* are " Loop long, composed of two ribbon-shaped lamellæ with cruræ, the lamellæ uniting at their anterior extremities, and a more or less developed vertical lamellæ rises between." (p. 353). The two spires of *Waldheimia*, *W. Mawii* Dav. and *W. Glassii* Dav., (Brit. Foss. Brac. Sil. Sup., Vol. V, p. 76, 79) are both small forms from the Wenlock, the first from the upper, the second from the lower beds. The characters of the brachial apparatus of the former species were perfectly made out by Mr. Glass, who, with Davidson, did so much to elaborate these delicate internal structures of Brachiopods.

The character which unites all these early genera of the Terebratulidæ is the long loop. (See figures 1 and 3.)

Three genera of the Spiriferacæ, reported from the lower silurian are characterized by a considerable extension of what Davidson has called "the primary lamellæ of the spiral coils." These are *Zygospira*, in which the lamellæ are produced laterally and are connected by a long bridge or cross-bar, *Anazyga* of similar form but the bridge is attached near the front at the point where the first coil of the spiral turns toward the ventral valve and upwards, and *Hindella*, in which the departure between the primary lamellæ and the bridge was at the extreme front extension of the apparatus. (See figure 6.)

The association of these facts led me, several years ago, to think there was some natural relationship existing between the calcified apparatus of the two families, and a year ago I expressed in my course of lectures the belief that they were closely related, but the difficulty of showing the way in which one form could result from modification of the other was not removed. Coming again this year to the same place in my lecture course I attacked the problem anew and this time in a purely inductive way.

I analyzed the two forms and found in each a thin calcified lamella, (*l*) proceeding downward from the cural process (*c*) following the curve of the inside of the dorsal valve (*d*) in the Spiriferidæ, continuing to the front, then curving upward along the inside of the ventral valve (v, fig. 7) to near the crural process—but curving outward and following the same course to form a spiral coil (*s*.) The primary lamellæ of the coils of the two sides are joined by a cross-bar (*b*) somewhere between the points of the crura on the front extremity of the primary lamellæ before they begin their upward turn. (See figures 5, 6, 7.)



In the Terebratulidæ, there are the same calcified lamellæ (l. figs. 1, 2, 3 and 4) from each of the cruræ (*c*) in the same way following the curve of the inside of the dorsal valve (*d*) toward the front (*f*); at the front they turn backward, forming a loop (*p*) by folding, so that the exterior surface (facing the side of the shell) of the primary lamella becomes the interior face of the part which is bent upward to form the loop. In the living forms there is, proceeding from the backward folded end of the loop, a coil (*a*) of fleshy spiral aims—but the direction of the coiling is the reverse of that of the spire (*s*) of the Spiriferidæ, that is, when viewed from the side the primary coil of the spire passes from the upper end of the calcified loops toward the neutral valve and follows the curve of the inside of that valve towards the front when it approaches the dorsal valve and curves backward towards its origin. (Compare figures 4 and 7.)

The conclusion which I felt safe in drawing, was that the spiral coils, calcified in the extinct Spiriferidæ, were the supports of fleshy brachiæ, as in the living Terebratulidæ, and the question which arose was how to explain the difference in direction of coiling of the arms in the two types. The solution of this problem resulted in explaining the relationship of the two families.

The difficulty was so great, that I made some models of the lamellæ of thin brass and made spiral coils of copper wire and experimented with the models to see how one could be changed into the other.

With this device, imitating the characters of the loop of the living *Waldheima* and its fleshy spiral arms, I discovered that doubling back the lamellæ with the spirals attached beyond the bend caused a reversal of the direction of the coil from that presented by it when attached before the bend, thus producing the exact difference observed on comparing *Waldheima* and *Anazyga* (see figs. 2 and 6.)

This experiment showed that the fundamental difference between the brachial apparatus of the two families does not consist alone in the presence of a calcified spiral in one and its absence in the other, but in the fact that in the Spiriferidæ the primary lamellæ are continued directly into the spiral coils, whereas in the Terbratulidæ the primary lamella on each side is doubled back upon itself to near the position of the mouth from which point the spiral part of the arm begins, the reversal of direction of the coils of the spiral resulting from this reflexion of the primary lamellæ.

This difference and the relationship is best seen in the earlier types, as *Anazyga* (fig. 6.) (See also *Dayia*, fig. 7), and *Waldheimia* (figs. 2 and 4). In both of these forms the primary lamellæ (*l*) are long, but in *Anazyga* and *Dayia* the bridge (*b*) connecting the lamellæ of the two sides sets off before the beginning of the spiral coil, while in *Waldheimia* (4) the bridge, or connecting part (*b* of fig. 2), does not occur till after the reflection of the lamellæ to form the loop.

In the short-looped Terebratulidæ (*Terebratulina*, etc.,) the primary lamellæ are not calcified down to the front and the reflected and looped part of the apparatus is not supported by calcified lamella. In the greater number of the genera of spiral-bearing brachiopoda (the Helicopegmata) the bridge connecting the lamellæ is higher up than in *Anazyga*, *Zygospera* and *Hindella*. Thus pointing to the conclusion that the earlier forms were all with long primary lamellæ, and that the forms in which the primary lamellæ were so far extended forward as to be reflected backward before the coiling of the arms, developed into the Terebratulidæ in which no calcified support for the coils was produced, and that the forms in which the lamellæ were continued directly into the spiral coils without reversal of direction became the Spiriferidæ, in which the spiral coil of the arms is supported by calcified lamellæ.

From these facts I inferred that the two families at the stage of their differentation, in the lower Silurian or earlier, were a continuous series differentiating from a common stock.

With this interpretation of the relations of the several forms to each other, we conclude that the Pegmatobranchia were developed from, or, strictly speaking, show closer affinities with the primitive stock than with any particular family of the Eleutherobranchia, and as a suborder find their natural place between the two divisions of the Eleutherobranchia, for which I would propose the subordinal names, *Orthidacea*, to include the Orthidæ, Strophomenidæ and Productidæ and *Pentameracea* to include the families Pentameridæ, Rhynchonellidæ and Porambonitidæ.

The following table will express the phylogenetic relations of the several families suggested by the above considerations.

Pentameracea (H. S. W.)	Rhynchonellidæ. Pentameridæ. Porambonitidæ.
Pegmatobranchia (Neumayr.)	Terebratulidæ. Thecididæ. Stringocephalidæ. Spiriferidæ. Koninchidæ.
Orthidacea (H. S. W.)	Orthidæ. Strophomenidæ. Productidæ.

The paper was illustrated by a model of the spiral "arms" and was discussed by the PRESIDENT and others.

MARCH 28, 1892.

STATED MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

A large audience present.

The PRESIDENT announced that MR. JOSEPH B. FULLER had presented to the Academy his very valuable herbarium, and read the following report from the Curator of Botany, MISS FLORENCE BECKWITH:

"The Academy is again the recipient of an addition to its collections. Mr. Joseph B. Fuller, of this city, has presented to the Society a collection of pressed plants for its herbarium. The collection comprises over 2500 specimens, representing more than 900 species, and is very valuable on many accounts. It was begun in 1851 when a great portion of what is now within the limits of the city was covered by the forest, and when the banks of the river, on both sides from the upper falls down, afforded a rich field for botanists. Many of the specimens were rare when they were collected, and great numbers of them are now extinct in the localities in which they were found. Any one who botanizes over this field now, will sadly realize that our native flora is fast being exterminated, and a collection which shows what once grew here will be more and more valuable every year. The specimens also represent years of patient study and careful research, and are especially valuable for the correctness with which they are named.

"They do not represent local flora exclusively, quite a number of them being from the White Mountains and some from the western prairies and other parts of the United States. Mr. Fuller modestly calls it a collection of dried plants, but it is a herbarium in itself, and we are particularly fortunate in being favored with the gift."

The PRESIDENT further announced that PROFESSOR S. A. ELLIS had presented to the library of the Academy the four volumes of "Contributions to the Natural History of the United States," by Louis Agassiz.

A written report from the committee appointed at the meeting of February 29, to represent the Academy in urging upon the State Legislature the necessity for a topographical survey of the State was read by the President. The State Engineer in a letter to the committee announced that the combined efforts of those asking for the survey had already resulted in partial success, in securing a small appropriation for the work this year from the Legislature, with good prospects for further success.

The PRESIDENT announced the death of a member of the Academy, MR. ROBERT BUNKER, who had been a faithful member and who had presented to the Academy his entomological collection. The President said it would be eminently fitting for the Academy to take some action in regard to Mr. Bunker's death.

On motion the following committee was appointed by the President to draft and transmit to the family resolutions of regret and sympathy.

MR. WILLIAM STREETER,
MR. JAMES W. ALLIS,
PROFESSOR S. A. ELLIS.

The third lecture of the Popular Lecture Course was given by PROFESSOR HENRY S. WILLIAMS of Cornell University, entitled :

THE MARCH OF THE GIANTS.

The lecture was illustrated by lantern views.

APRIL 11, 1892.

BUSINESS MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

Fifteen persons present.

The PRESIDENT announced that there would be no report from the COUNCIL, as they had been unable to hold a meeting. He thought the best plan would be to postpone regular business and, after the remainder of the program for the evening had been carried out, to adjourn to Monday evening, April 18.

On motion all business was postponed for one week.

The PRESIDENT announced that the Secretary, MR. FRANK C. BAKER, had resigned and said some action should be taken in the matter of securing a person to act as Secretary until an election could be held.

On motion MR. Baker's resignation was accepted, and DR. P. MAX FOSHAY was elected Acting Secretary.

The President introduced DR. P. MAX FOSHAY, who read a paper entitled :

THE LATEST PHASE OF THE ARYAN CONTROVERSY.

APRIL 18, 1892.

ADJOURNED BUSINESS MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

Seventeen persons present.

The COUNCIL report recommended :

(1.) The election as active members of the following persons :

MR. CHAS. D. CHICHESTER,
MR. CYRUS F. PAINE,
MRS. JOHN WALTON,
MR. E. H. GRIFFITH,
DR. FRANK F. DOW.

(2.) The election as life member of MR. JOSEPH B. FULLER.

(3.) The payment of certain bills.

(4.) That the price of extra volumes of the Proceedings be fixed as follows :

One volume to members, - - -	$2.00
" " to non-members, - -	3.00
Single brochure to members, - -	1.00
" " to non-members, -	2.00

The members were elected as recommended. The bills were ordered paid and the prices fixed on extra volumes of the Proceedings.

On motion a vote of thanks was extended to PROFESSOR S. A. ELLIS, for the valuable gift to the Academy's library of Louis Agassiz's "Contributions to the Natural History of the United States."

The following paper having been accepted for publication by the Council was read by title :

ON THE SEPARATION OF MINERALS OF HIGH SPECIFIC GRAVITY.

By E. W. Dafert, M. A., Ph. D. and O. A. Derby, F. G. S.

(*Communicated from the laboratory of the Commissão Geographica e Geologica de São Paulo, Brazil.*

The various processes that have been devised during the past few years for the separation of fine grained mineral mixtures by means of heavy liquids, the electro magnet, etc., have greatly extended the field of mineralogical and petrographical research and are of almost daily application in the laboratory. By their use, the rarest accessory elements may be quickly and readily isolated from the superabundant essential elements and, within certain limits, separated from each other, for the purposes of study and identification. The application of the *batea* described by one of us in a recent number of this journal, renders practicable the obtaining of sufficient quantities for analysis of these rare and fine grained minerals, and thus their separation in a state of purity becomes a matter of great importance.

The limit of complete separation by means of heavy liquids is at present fixed at sp. gr. 3.60–3.65, obtained by Retgers (*Neues Jahrbuch, 1889, II. p. 188*) by saturating methyline iodide with iodoform and iodine. This limit has been extended to sp. gr. 5 by Bréon and Retgers, by the use of fused zinc, tin and silver salts, but these processes have, in our hands at least, proved very tedious and unsatisfactory. Under the most favorable hypothesis, the process by fusion does not dispense with the subsequent sorting under the lens, since the operator cannot follow the separation closely with the eye and the division of the cooled ingot at the proper point is a matter of chance.

The separation by the electro-magnet is limited by the magnetic properties of the minerals and, even when applicable, is seldom so complete as to dispense with the use of the lens. In general, therefore, it may be said that above sp. gr. 3.6 and with minerals that do not vary greatly in magnetic properties, the most that can be obtained is a *concentration* of the different minerals in different portions, that greatly facilitates the process of sorting.

In seeking a process of general applicability that would at least give a satisfactory concentration, it has seemed to us that the best hope of a solution was to be found in the principle of a moving column of liquid, long employed for an essentially different purpose in agricultural chemical laboratories. A very neat little apparatus for this purpose has already been devised by M. Thoulet (Fouqué et Lévy, *Minéralogie Micrographique, p. 120*) but it does not appear to have come into general use. The essential defects of the method have been indicated by Prof. Rosenbusch (*Mik. Phys. 1885, I., p. 206*) as follows : " The separation of a mixture of different minerals of equal grain through the mechanical effect of a stream of water is not obtainable with any degree of exactness ; the division takes place principally according to size and form of the grains, so that flakes are moved more readily than grains, and not according to the specific gravity, even when this is very different among the components of the mixture." This condemnation of the principle is, however, too absolute as will be seen by the results obtained by the apparatus described below. Once that the idea of *complete separation*, impossible to obtain above sp. gr. 3.6, is abandoned, and we content ourselves with a more or less satisfactory *coucentration*, the principle objections to the process disappear and, with the improvements of which it is susceptible, it becomes a valuable aid in the laboratory.

*1. Description of the Apparatus.**

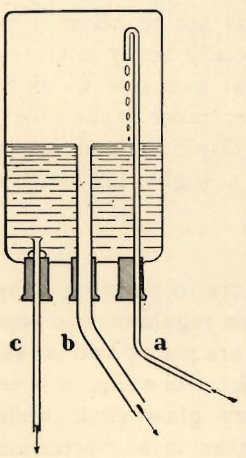


FIG. 1

Starting on the basis of the Thoulet apparatus, we have modfied the separator (fig. 2) in such a way as to permit the withdrawal of the lighter material in a perfectly regular manner without disturbing the operation (thus incidentally making the apparatus continuous in its action) and to do away with secondary currents within the tube. To this, we have added the accessories (figs. 1, 3 and 5) for securing, automatically, regularity in the current.

The pressure regulator (fig. 1) may be made from a simple Wolff flask and should be placed at about two meters, at most, above the work table. The dimensions of the single parts are : cubic contents of flask, 2 liters ; diameter of tube *a*, 3 mm.; of tube *b*, 10 mm.; of tube *c*, 3 mm.

* The apparatus here described can be obtained from C. Gerhardt, Marquarte Lager, Bonn.

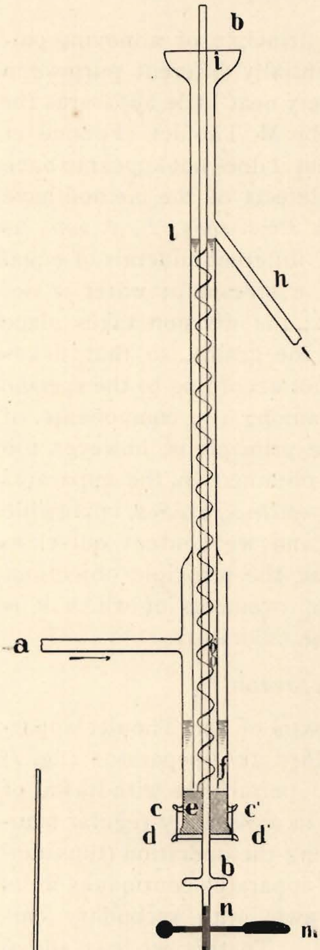


FIG. 2

The regulator is connected by glass and rubber tubing with the separator (fig. 2). The latter consists of two distinct parts of glass, the separating tube proper *l*, *a*, *h* and the draw-tube *b*. The liquid enters at *a*, flows at *f* in the closed space of the inner tube *g* and mounting upward to *l* escapes by the tube *h*. The rubber cork *e* must close the tube *g* in such a way as to leave only a small circular passage. With a little practice it is easy to place the cork so as to fulfill this condition and to regulate the entrance of the liquid in the tube *g* at will. Inside of *g* is a loose spiral of fine platinum wire of about ¼ mm. diameter and with about 40 coils of 5.5 mm. diameter, the object of which will be explained later.

The substance to be separated is introduced through the funnel-shaped opening *l* and remains wholly in the tube *g* which should be so arranged with reference to the cork *e* as not to allow it to escape. If in especially heavy mixtures, grains accumulate at one side so as to partially close the entrance to the tube *g* they can easily be displaced and set in motion by giving a slight tap to the apparatus.

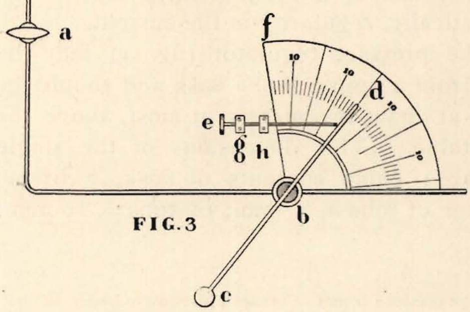


FIG. 3

In the connecting tube between regulator and separator are placed two cocks, of which one *a* (fig. 3) is an ordinary glass cock, while the other is a "precision cock" whose construction is readily seen from figs. 3 and 4 and which will be referred to farther on.

The dimensions of the apparatus with which experiments have been made are: fig. 3, diameter of tube and cocks, 4 mm.; fig. 2, diamter of *a*, 4 mm., *f* 10 mm., *g*, 7 mm., *b*, 3 mm.; height of *f*, 140 mm., *g*, 330 mm, *b*, 520 mm., to *l*, 280 mm.

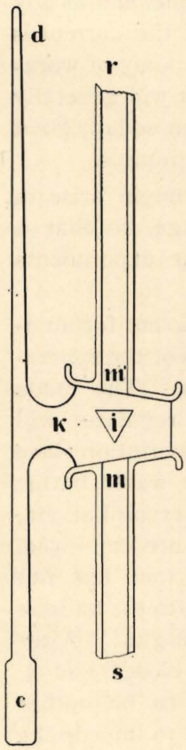


FIG. 4.

The technical points that were kept steadily in view in devising the apparatus are the following:

1.—Water is preferable to all other liquids for the purpose of separation.

2.—One must not only be able to sharply regulate the velocity of the current, but also to re-establish it at any given time with approximate accuracy.

3.—In any given sand the separation according to specific gravity is only possible when,

(*a.*)—The mixture to be separated is as far as possible of equal grain, in which is included not only equality as regards volume, but also, so far as possible, similarity of form as well.

(*b.*)—When the substance to be separated never can leave the liquid column, settle in some point outside of it, come irregularly into motion and then remain at rest, etc.

(*c.*)—When in the moving column of liquid the current is as uniform as possible, and, especially, moving in all parts in the same direction.

(*d.*)—When the apparatus in no place affords an opportunity for the formation of "false currents," as for example, at the joints which may form eddies in the current and thus impede a regular separation.

(*e.*)—When after the arrangement in the current of the mineral elements according to specific gravity, the withdrawal is effected without disturbance of the pressure or of the direction of the current in the fluid column.

(*f.*)—When the current is as weak as practicable, and finally

(*g.*)—When the operation of separation can be repeated as often as may be desirable.

Numerous experiments with different forms of apparatus and under various conditions for the purpose of determining how far these theoretically desirable points are attainable in practice, lead to the following conclusions:

1.—A priori, it would appear that the denser the liquid employed, the more complete should be the separation, because the same lifting power could be obtained with a weaker current. Contrary to our expectations, we found that the difference between the action of a current of water and one of the Thoulet solution is not sufficient to make the employment of the latter advisable, and as any advantage derived from a weakening of the force of the current is more than compensated by the greater facility and economy of working with water. A repetition of the process with water will generally be found more satisfactory than an attempt to obtain an equally good separation with a single operation by the use of heavy liquids.

In dealing with extremely heavy minerals, cases might arise in which the use of heavy liquids would be of advantage, so that a description of the apparatus fig. 5, employed in our experiments will not be out of place.

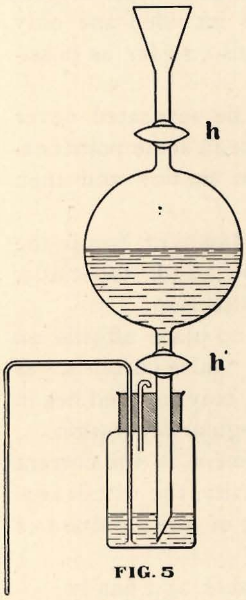


FIG. 5

200 cu. cm. of liquid are sufficient for uninterrupted work. The other parts of the apparatus require no special alteration. The mode of mounting and operating the regulator will be understood without further description since it has long been employed for water baths. For convenience in filling the reservoir balloon, two rather wide cocks, *h* and *h'* are employed. From time to time the liquid that has run through the apparatus is restored to the balloon by opening the cock *h* and closing *h'*. After pouring in the liquid, *h* is again closed and *h'* opened. These cocks require to be rather wide (about 10 mm.) in order not to impede the passage of air at *h* and of the liquid at *h'*.

2.—The problem of regulating the current is solved with sufficient accuracy by the arrangement shown in figs. 1, 3 and 4. Fig. 1 is the pressure regulator kept at a constant level by the overflow tube *b*. After opening the cock in connection with the supply tube *a*, the regulator requires no further attention. The flow is regulated by the cocks *a* and *b*, fig. 3. The first is for coarse adjustment, rapid opening or closing, etc. The second, on the contrary is a "precision cock," whose special features (scale, counterpoise and triangular valve) are seen in figs. 3 and 4. The necessary sensibility of the cock is obtained through "a triangular opening working in a circular socket" instead of the usual circular opening. The wax that the glassblowers are so fond of putting in their cocks must be carefully removed before using, as its presence makes the regulation of the flow impossible.

3.—The condition *a* cannot be completely satisfied. A close approximation to regularity of grain may however be obtained by the use of fine sieves (bolting cloth makes the best) and by repeating the separation in water with a strong current and a higher column of sand. It must be confessed, however, that this is the weak point of the apparatus and that we have only partially succeeded in removing the difficulties of a difference in the size and form of the mineral grains. If a solution of this problem were practicable, it is evident that the method would be the most complete imaginable. This, however, is impossible and in practice we have found that with careful work, the difficulty can be so far overcome that, notwithstanding this defficiency, the method is very useful.

The conditions *b*—*e* are almost completely satisfied in the apparatus above described, as a simple inspection will show, whereas in all the previously devised separators that have come to our knowledge a regular separation is excluded by the very form of the apparatus.

In observing the motion of the particles in any ordinary separating apparatus, it will be seen that even in the narrowest tube, grains of equal size and specific gravity show by sinking, the existence of a counter current that renders impossible a separation according to specific gravity. This difficulty may be overcome in three ways :

(*a*)—By provoking a circular motion in all the mineral mass floating in the liquid column, by twirling the apparatus.

(*b*)—By producing a spirally flowing water column which will force back into the current at another point, every mineral particle that gets out of the current.

(*c*)—By the introduction in the current of a spiral which diverts the counter currents and throws them again into the proper upward flowing stream.

All three of these are technically practicable. They also appear to be of equal efficiency when certain conditions are satisfied. We have chosen principle *c* as being the simplest to arrange in the apparatus. An experiment with and without the spiral will show a marked difference in the practicability of the process of water separation. We should remark that the spiral should neither rest on the inner nor the outer tube, and therefore the diameter of the coils should be larger than that of the inner tube and smaller than that of the outer one. The proper thickness of wire to produce the best results may be determined by experiment within the limits fixed by the above condition.

The fulfillment of conditions *f* and *g* rests with the operator.

II. Manipulation of the Apparatus.

We give below a somewhat detailed description of the mode of operating our apparatus, because it often happens that, from inobservance of certain rules or ignorance of certain wrinkles, a new contrivance is frequently put aside as worthless, that with more careful testing has given very good results.

In operating the apparatus, the following order should be observed :

1.—The water regulator is prepared for the whole duration of the operation by opening the cock to the supply tube *a*, fig. 1.

2.—After carefully joining together the different parts of the apparatus, the cock *a*, fig. 3, is opened and water slowly admitted into the separator. It is important that no air bubbles are allowed to remain in the connecting tubes and that the water should rise to the height of a few centimeters in the space *f*. The exclusion of bubbles may be easily effected by filling the space *f* from a wash-bottle before joining the separator and regulator, and by filling in the same manner the rubber tube by which these two parts are joined.

3.—Before the liquid column reaches the point *l*, (fig. 2,) the lateral tube *h* is closed with a rubber tube and screw-clip and the whole apparatus is then filled up to the funnel *i*, when the cock *a*, (fig. 3,) is again closed.

4.—The mineral mixture is introduced through the funnel *i*. The particles sink and lodge in the space *g*. The size of the grains must not be too great to move freely in this space so that in the case of a coarse sand, a larger apparatus than the one here described may be required. The amount to be operated upon at one time will naturally depend upon the size of the space *g*, which should not be over a quarter full. In our experimental apparatus, we have operated upon about two grammes at a time. The apparatus will operate equally well upon very much smaller amounts, and is *continuous* in its action, since it is clear that, after the first portion is withdrawn, another can be added without any derangement of the apparatus.

5.—After the introduction of the material, the screw-clip on the rubber overflow tube attached at *h* is opened and all the liquid above *l* allowed to run off, while any grains that may have remained adhering to the tube above *l* are washed down by a spirt from the wash-bottle. By operating carefully, that is, slowly, in the introduction of the mineral, there is not the slightest danger that the grains in falling into the space *g* will lodge in the tube *h* and thus be lost. If by chance any do so enter, they may be easily recovered by drawing off the water from *h*.

6.—The separation proper may now commence. The cock *a*, (fig. 3,) is opened, and *b* is so regulated as to set the mineral mass slowly in motion. This operation requires some care, as not infrequently the sand hangs together and only after a little time, moves as separate grains. A slight tapping of the apparatus is often of good effect at this point of the operation. The current should be so regulated as to raise the column of moving sand to near the point *l*, taking care, however, not to allow it to enter the tube *h*. In a short time the lightest and heaviest grains will be seen to be concentrated at the highest and lowest parts of the column respectively, while in the median portion of the column are the minerals of intermediate specific gravity mixed with the larger grains of the lighter and the smaller of the heavier minerals.

7.—The withdrawal of the sand in as many successive portions as may be desired, commencing with the lightest, is effected by lowering the tube *b* until its upper opening reaches the point at which a separation is desirable. Care should be taken to do this so gradually as not to lower the level of the liquid at *l* whereby the force of the current would be influenced. As soon as the upper end of the tube reaches the column of moving sand, the grains that pass its level sink quietly and regularly into it, without in any way influencing the separation still going on at the lower levels. By opening the spring-clip *m*, the contents of the tube *b* can be drawn off at any time. This operation should also be effected with care so as not to bring the level of the liquid column below *l* and so alter the pressure. It is clear that by successive lowerings of the tube *b*, the entire contents of the apparatus can be drawn off in as many portions as may be desired. A good plan is to draw off liquid enough from *b* to bring the sand accumulated in it into the free portion below the cork where the separated part can be readily examined with a lens and the proper level for the tube, or the proper time for drawing off, be thus determined more accurately than by watching the moving grains in the apparatus.

If the object in view is to obtain a quantity of the heavier element alone, a useful wrinkle is to combine this method of drawing off with that of an alternating weaker and stronger current so as to send into the tube *b* the grains of mean specific gravity along with the lighter ones, the tube in this case being lowered down to the level at which, with the normal current, the lowest of the lighter grains swim. In this way, for example, we have obtained nearly pure monazite (sp. gr. 5) from a mixture with titaniferous iron (sp. gr. 4.75.)

8.—With a fine adjustment of the current and a repetition of the process on the parts already passed in the apparatus, the separation may be made nearly perfect. As the withdrawal of material is perfectly under control and as uniformity of grain can be nearly obtained by repetitions of the process, the rest depends on the skill of the operator and particularly on the facility with which he recognizes the different minerals in the dancing column of sand within the tube. Naturally the composition of the sand operated upon and the relative specific gravity of its different elements should be previously known from a preliminary examination, and the movements of some mineral that, from its well characterized color or aspect, can be readily followed by the eye, should be taken as a guide. If the mixture does not already contain such a characteristic guide mineral, it is advantageous to add a few grains of one, which can afterwards be separated by the electro-magnet or by picking out under the lens. Garnet, ruttle, titaniferous iron, zircon and monazite give a good range of color and specific gravity from which selection for this purpose can be made, and, in any collection containing numerous samples of sand, will almost always be at hand.

To test the process, the heavy residue from a decomposed muscovite granite was passed once through the apparatus, withdrawn in two portions, and the different minerals completely separated under the lens and weighed. The sand was prepared by passing through a Thoulet solution of about specific gravity 3, partially cleaned of iron minerals with the electro-magnet and screened between bolting cloth Nos. 1 and 4 (20 and 25 holes to a centimeter). The residue then consisted principally of titaniferous iron, monazite and xenotime with a few grains of staurolite, tourmaline and muscovite, the total quantity being 1.77 grammes. The following table gives the percentages of the three principal minerals in the original sample, in the lighter (I) and heavier (II) portions, and those of the total amount of each mineral in the two portions

	Original Sample.	Part I.	Part II.	% To Total in I.	% To Total in II.
Xenotime (sp. gr. 4.45 ±) -	18.5%	26.5%	6.3%	86.5%	13.5%
Titaniferous Iron, (sp. gr. 4.75 ±)	31.95	45.0	12.1	84.9	15.1
Monazite, (sp. gr. 5 ±) - -	49.6	28.5	81.6	34.7	65.3

In another test on about three grammes of the same residue screened between Nos. 4 and 5 bolting cloth (25 and 27 holes to a centimeter) and withdrawn in three portions, light (I), medium (II) and heavy (III), the result was as follows :

	Original	I.	II.	III.	% in I.	% in II.	% in III.
Xenotime, -	23.6%	36.7%	42.2%	11.8%	7.5%	62.3%	30.2%
Titaniferous Iron,	19.5	14.4	33.3	11.9	3.5	59.5	37.0
Monazite, - -	56.9	48.9	24.4	76.3	4.1	15.0	80.9

These results obtained at a *single* operation with an improvised experimental apparatus in which, from the lack of proper materials, neither the regulating cock nor the spiral could be arranged to our complete satisfaction, show very clearly the capabilities of the process. It should be remarked that in the second table the showing is not as good as it should be since part I contained a considerable amount of lighter minerals (tourmaline, staurolite, limonite, muscovite and quartz) mingled with such fine fragments of monazite and titaniferous iron, that no attempt at a complete separation by picking out was made except for the xenotime. All the dark colored grains in this portion were reckoned as iron and all the light colored ones, not clearly xenotime, as monazite, so that the percentage of the heavier minerals are altogether too high in the second column. Even so, however, the percentages to the total of each mineral in this portion are very satisfactory. The sand was a particularly difficult one to deal with on account of the fragmentary condition of a part of the monazite grains causing great variation in shape which impeded the grading by size in the screens.

It will be noticed that while the concentration of the monazite is most satisfactory in the second operation, that of the lighter minerals is best in the first. This is due to differences (voluntary or otherwise) in the manipulation of the draw-tube and shows the impossibility of obtaining *constant* results owing to the personal equation of the operator, that is to say, on his quickness of eye in following the dance of the different colored grains and on his judgment as to the proper height of the draw-tube and the proper time for drawing off the sand accumulated in it. It will readily be seen that practice will make a vast difference in these respects, so that with a little use, results more perfect than those above recorded may be expected.

The PRESIDENT read a paper entitled :

A DESCRIPTION OF SOME PLANTS OF THE COAL ERA.

The paper was illustrated by charts and fossils and was discussed by MR. PUTNAM, DR. FOSHAY and others.

APRIL 25, 1892.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

A very large audience present.

On motion all business was postponed.

The fourth lecture of the Popular Lecture Course was given by DR. H. CARRINGTON BOLTON, of New York, entitled :

FOUR WEEKS IN THE WILDERNESS OF SINAI.

The lecture was illustrated by lantern views.

MAY 9, 1892.

BUSINESS MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

Thirty-three persons present.

The COUNCIL report recommended :

(1.) The election of the following persons as active members :

MR. E. R. ANDREWS,
MR. MARSENUS H. BRIGGS,
HON. GEO. F. DANFORTH,
MR. WM. EASTWOOD,
MR. W. H. GORSLINE,
MR. MONTGOMERY E. LEARY,
MRS. HELEN M. MILLER,
MRS. HOWARD OSGOOD,

MR. C. M. EVEREST,
MR. JAS. P. FLEMING,
MR. DAVID HAYS,
Mr. A. M. LINDSAY,
REV. HOWARD OSGOOD,
MR. IRA L. OTIS,
Mrs. CHARLES B. POTTER,
GEN. JOHN A. REYNOLDS,
MRS. RUTH SIDDONS,
MR. JOHN F. BRAYER,
MR. G. HANMER CROUGHTON,
HON. JOHN M. DAVY,
MRS. WM. EASTWOOD,
MR. JOHN FAHY,
MR. GILMAN H. PERKINS,
MR. JOSEPH E. PUTNAM,
MR. CLINTON ROGERS,
MRS. EDWARD MEIGS SMITH,
REV. H. H. STEBBINS,
MR. GEO. F. SLOCUM,
DR. HENRY T. WILLIAMS,
DR. CHARLES T. HOWARD,
DR. EDWIN BANTON,
MRS. H. H. STEBBINS,
MR. EDW. H. VREDENBURG,
MR. THOMAS G. YOUNG,
MR. ALBERT C. WALKER,
MR. T. J. SARLE.

(2.) The election of the following members as Fellows :

MR. JOSEPH B. FULLER,
MR. E. H. GRIFFITH,
MR. A. M. DUMOND,
PRESIDENT DAVID J. HILL,
DR. P. MAX FOSHAY.

(3.) The payment of certain bills.

On motion the rules were suspended and the candidates for active membership were elected at once. The bills were ordered paid.

The Corresponding Secretary, PROFESSOR CHARLES W. DODGE, made a report and read letters from a number of corresponding members, among whom were : PROFESSOR W. W. DUDLEY, MR. G. K. GILBERT, PROFESSOR JOSEPH LEIDY, PROFESSOR H. S. WILLIAMS, DR. CHARLES S. DOLLEY, DR. H. CARRINGTON BOLTON and MR. CHAS D. WOLCOTT.

MR. GEO. W. RAFTER read a letter from DR. A. C. MERCER, asking the Academy of Science to take some action in the matter of a testimonial which it is proposed to give to DR. R. L. MADDOX of England, the inventor of the photographic dry plate.

On motion the following committee was appointed by the President with power to act in the matter:

MR. GEO. W. RAFTER,
DR. CHARLES FORBES,
DR. J. EDW. LINE.

The President now introduced Dr. M. A. Veeder, who read a paper entitled :

THUNDERSTORMS,

By M. A. Veeder.

The present study of thunderstorms has grown out of the research in regard to auroras and their associated conditions, some of the results of which have been presented before the Academy and published in the proceedings in previous years. In general it has been found that auroras and their attendant magnetic storms occur when spots, or faculæ, or both are at the sun's eastern limb, and near the plane of the earth's orbit. Inasmuch as the proofs of this proposition have an important bearing upon the subject of thunderstorms, and may not be accessible to many receiving this paper, it is necessary to rehearse them somewhat at length.

By counting the stations reporting auroras each day and arranging the numbers thus obtained in periods, it is found that the time of recurrence is twenty-seven days six hours and forty minutes. This result was obtained within four minutes from magnetic observations alone. The four minutes were added after it had been discovered that this slight lengthening of the period would secure conformity with Carrington's determination of the time of a synodic revolution from the average rate of rotation of spots, which value also has been adopted at the Greenwich Observatory.

So far as is known to the writer this determination has never been made in the case of magnetic phenomena with such accuracy heretofore. Round numbers and general statements based upon records from too few stations or for too short a time, are entirely inadequate for the purposes of the present investigation. It is not enough to know that there is recurrence at intervals of about a month. The limits of probable error should be less than any considerable fraction of even a single day. The tables upon which the period that has been named is based cover nearly two hundred years, and comprise nearly all reports of auroras in existence, as well as records of magnetic storms for a considerable number of years. These tables are so voluminous that only specimen extracts, such as that appended to the paper upon the Zodiacal Light in the Proceedings last year, have been published. This extensive and thorough tabulation has reduced the limit of probable error to a question of a few minutes more or less. An error amounting to as much as half a day would multiply itself so as to become a whole week in the course of a single year, and would be very plainly perceptible in tables such as those which have been constructed. Thus there is no liability whatever to confusion with the time of a synodic revolution of the moon which differs more than two days from the period of auroral recurrence. On the other hand the conformity with the rotation period of the sun is exact, and is capable of verification in ways that will appear in the further course of the discussion.

The evidence being so clear that there is recurrence of auroras at the interval of a synodic revolution of the sun, it becomes of interest to compare their daily prevalence with the coincident condition of the sun's surface. For this purpose suppose the entire surface of the sun to have been divided meridionally into as many lunes as there are days in the synodic interval, and make for each of these divisions a list of the sizes of all sun-spots observed each day throughout the year as given in the Greenwich Records of Photographic Results. From these records also it is known where each lune was located upon any given day or series of days. Upon the first day of each auroral or synodic period for example, each lune returns to a particular part of the sun's disc, which in turn is occupied on the next day by the lune following and so on. By this method it is learned that upon series of dates characterized by recurrence of the aurora, disturbed portions of the sun are always at the eastern limb appearing by rotation. It is true that for many years past instances have been numerous in which at the time of an aurora a disturbance has been located just west of the meridian, but this latter relation is adventitious and depends upon the fact that the chief seats of solar activity recently have been three in number and about nine days apart so that when one is at the eastern limb another is apt to be just beyond the meridian. In years when there is cessation of activity at one or more of these centers it becomes evident that it is the eastern limb effect that persists, that assumed to proceed from the meridian disappearing when the disturbances are far enough apart to avoid any possibility of confusing the one with the other. It is to be noted also that at times when all these centers are active at the proper interval from each other there is increased liability to confuse the direct effect of a disturbance at the eastern limb with that of the one next preceding because of the fact that when an aurora appears there seems to be a reactionary inductive effect from the earth itself towards the sun which tends to increase the size of any sun spots near the meridian in a manner that will be more fully explained in a subsequent paragraph in which sun spots are shown to depend upon a reflux of magnetic induction toward the sun whenever its surroundings become more highly charged.

That this relation of auroras and magnetic storms to the location of disturbed areas at the eastern limb is not adventitious is shown also by the manner of recurrence. At each return the beginning is abrupt and strong, and the subsequent decline gradual. This is apparent in the case of auroras, but is best seen in the tracings from the magnetographs which record magnetic storms automatically. For example, the outbreaks of February 13th and March 12th, 1892, were distinguished by phenomenal characteristics, and began suddenly and violently at the exact interval of twenty-seven and one-quarter days. Consequently the originating solar disturbance could not have undergone any change of location whatever on the sun's surface, its magnetic effect recurring at an interval differing but a few minutes from the synodic period obtained as the result of the present research. If in such a case the originating disturbance were at the meridian, or elsewhere than at the eastern limb, it is possible that there might be abruptness and violence of beginning but there could not be such exactness of periodicity corresponding to the time of a synodic revolution of the sun.

The tables to which reference has been made show also that these recurrences of the aurora are not continuous, but are best defined near the equinoxes, and almost disappear near the solstices. In numerous instances single series of recurrences at one equinox do not reappear in the same location in the tables until the return of the corresponding equinox in the year following. This happens even in years in which the disturbed condition is constant, so that disturbances even when large and active fail to exercise their full magnetic effect at all seasons of the year. No hint as to the explanation of this was secured until the latitude of the disturbed areas was taken into the account, whereupon it became apparent that proximity to the plane of the earth's orbit is requisite. Spots and faculæ are not scattered promiscuously upon all parts of the sun but are confined to narrow belts at a distance of several degrees north and south from the equator. Because of the inclination of the sun's axis to the plane of the earth's orbit, it is only at the equinoxes that the earth approaches the heliocentric zenith of one or the other of these belts. Whatever may be the explanation it is only when thus in range that the earth experiences the full magnetic effect. Thus when a disturbed area is upon one side of the sun's Equator solely, its effect reaches the earth only while the latter is opposite the corresponding hemisphere. In the paper upon the Zodiacal Light presented to the Academy last year, evidence was adduced which tends to show that this behaviour of magnetic storms and auroras may depend upon a peculiar disc-like distribution in space of the meteoric debris surrounding the sun, which becomes visible as the lateral extensions of the corona seen during eclipses and as the zodiacal column and which has the requisite physical properties and location to serve as a conducting medium under the limitations actually found to exist.

It is possible that the red sunset glows whose revival has been recently reported in the absence of volcanic eruptions may be due to dust of cosmical origin as well as to that from purely terrestrial sources as was thought to be the case following the eruption of Krakatoa in 1883. Certainly we are justified in inferring that such dust is present in interplanetary space and serves as a medium for the play of electrical discharges from the fact that what seems to have been a true aurora has been observed attached to the moon and moving with it. Such observations are necessarily rare, the appearance being commonly overpowered by the glare of moonlight, or it is disregarded as being nothing more than a mere cloud or halo. If however the observation is confirmed and the lunar aurora is found to be a reality, there being no atmosphere in that vicinity, it is positive proof that neither ice crystals nor air particles nor other atmospheric contents serve exclusively as the medium of conduction, but that the meteoric dust of interplanetary space has a part to perform. Thus also the peculiarities of the spectrum of the aurora are consistent with the idea that they depend upon the play of electrical discharges upon dust particles suspended in interplanetary space or practically in vacuo, under which condition there is increased facility of conduction and increased luminosity as is shown by ordinary vacum tube experiments.

Having thus identified to some extent at least, the conditions under which magnetic impulses arise we are in a condition to attack the thunderstorm question. It is to be noted that the thunderstorm is a very local affair, having but little if any effect on the magnetic needle. Consequently it is more difficult than in the case of auroras to secure information in regard to its daily prevalence, and it is impossible to check the results by comparison with the coincident behaviour of the needle. We are compelled for the most part to rely upon the history of out-breaks of marked severity, or at unusual seasons, as for instance, in the winter. This is less satisfactory than the systematic and very complete tabulation that is possible in the case of auroras. Still it is the best that can be done, and may afford important clues.

Thunderstorms being electrical it is natural to expect that they should be related in some way to auroras which also are of electrical origin. This expectation has been realized by the discovery that hunderstorms not unfrequently take the place of auroras in the regular order of recurrence. There seems to be a substitutive or reciprocal relation between these two classes of phenomena, the one taking the place of the other, wholly or in part, under conditions now in process of investigation, and with reference to whose study the present paper is essentially a report of progress.

Evidence has been secured which indicates that thunderstorms prevail most widely when disturbed areas are at the sun's eastern limb, and at a distance from the plane of the earth's orbit, thus differing from auroras in whose case, proximity to that plane appears to be essential. This difference in the location of the originating disturbance appears to modify the method of conduction of the electrical impulses, the earth in the one case being in exact range with lines of force and conducting medium experiences the species of impulse known as magnetic, and in the other case being somewhat out of range encounters instead disruptive discharges which fall at points where the attendant terrestrial conditions are most favorable.

There are resemblances between the behaviour of thunderstorms and auroras consistent with such community of origin. Both occur in well defined belts which undergo changes of latitude in corresponding cycles of about eleven years duration, and are concentric with the magnetic poles of the earth rather than with the axis of rotation, thus corresponding to a like arrangement of belts of equal atmospheric pressure. Both exhibit daily maxima and secondary maxima at certain hours of local time, depending upon concentration of effect at points which maintain a fixed position with respect to the source of induction but which are movable with respect to the earth itself. In the case of thunderstorms the chief maximum is in the afternoon and the secondary maximum between midnight and morning, even hail as well as thunder and lightning having been known to occur during the night. The corresponding maxima of auroras fall in the evening and early morning. Accordingly when an aurora in the eastern hemisphere is coincident with thunderstorms in the western and vice-versa, the substitution may depend in part at least upon this relation to certain hours of local time, as well as upon differences in respect to the humidity of the atmosphere and the like, affecting its conductivity. The system of concerted observation organized by the writer in which a large number of observers are participating has revealed a tendency to the localization of the aurora somewhat similar to that apparent in the case of thunderstorms but not so strongly marked. The conditions under which this localization of the aurora occurs appear to be connected in some way with the sharp bending of the lines of equal magnetic declination, as for example in the Adirondack region and Northern Maine and near the mouth of the Ohio River. There are laws also governing the relative prevalence of these phenomena at different seasons of the year which require further study from the point of view in regard to solar origin here indicated. It is sufficient for the purposes of the present discussion to point out that there is such similarity in the behaviour of auroras and thunderstorms in many important particulars as is consistent with their having a common origin.

Thunderstorms also exhibit definite relations to conditions of atmospheric pressure that appear to be under the control of these characteristic solar impulses. This may be shown in the following manner: From the Daily International Weather Maps the location each day of all centers of high barometer throughout the greater part of the northern hemisphere may be obtained. Thus it may be shown that at times these centers all suddenly begin to move eastward as if by a common impulse. This happens under the precise solar conditions that attend the aurora and thunderstorm. It is most pronounced near the equinoxes when auroras also are at a maximum. Associated with it at all seasons there is marked intensification of storms. This occasions the phenomenon of well-defined storm periods, but there is not one universal storm. On the contrary, anti-cyclones as well as cyclones are strengthened as atmospheric movements become more energetic, so that during these very storm periods the weather in particular localities is much finer than common.

Other evidence that the atmosphere as a whole is under the control of induction from the sun, is to be found in the fact, that in certain years when forces of this character are at a maximum, there is a re-arrangement of the distribution of atmospheric pressure on a grand scale. Anti-cyclones with greater heat in summer and greater cold in winter, become more persistent in high latitudes, and cyclones appear in the tropics, the belts of thunderstorms and auroras also descending to lower latitudes. In years of minimum on the other hand there are anti-cyclones and drouths in the tropics and cyclonic conditions in high latitudes, with cool summers and mild winters. In such years drift ice comes down from the Arctic regions all winter. Coincidently auroras and thunderstorms become less frequent and appear in higher latitudes.

The theory has been advocated that these re-arrangements of pressure and coincident peculiarities depend upon accidental terrestrial conditions. It has been said for example, that drift ice in the North Atlantic would produce unusual cold over the adjacent continents. That this is not so appears from what has just been stated in the preceding paragraph. It is precisely when the winters are mildest over the northern parts of Europe and America that such ice is most abundant.

It has been customary also to ascribe such wholesale re-arrangements in weather conditions to variations in the sun's power of heat emission. This has been done upon purely theoretical grounds, no direct evidence of any such variation having been secured by the exposure of properly arranged thermometers to the direct rays of the sun in the most favorable localities that can be found. Furthermore, when the averages from a sufficiently large number of stations are compared, it is found that the excesses and deficiencies offset each other in such a manner that the general result is but an insignificant departure from the normal. In other words, there are re-arrangements of distribution but the quantity remains the same. From the point of view of the present discussion the question as to the variability of solar heat resolves itself into an inquiry as to whether the inductive forces emanating from the sun under the limitations that have been pointed out are of a thermo-electric nature.

The periodicity corresponding to the time of a synodic revolution and the confinement of magnetic effect to a very small portion of each transit, which portion remains the same at successive returns, indicate that the motion of rotation and not heat radiation is concerned in the propagation earthward of these impulses. Rays of heat pass indifferently in every direction through a homogeneous medium such as is that surrounding the sun. Hence there is no possibility of accounting for the eastern limb effect by the agency of heat rays inasmuch as this would necessitate their emission in a single direction only. The same is true of light radiations. Whatever may be the merit of the electro-magnetic theory of light it does not apply in this case. In other words the magnetic effect of solar disturbances does not depend upon their visibility. If this were the case magnetic storms and auroras would continue all the while in certain years, whereas even when the sun is most disturbed continuance for as long a time as a single week is extremely rare.

It is the motion of rotation of portions of the sun's surface that have been electrified by the action of eruptive forces that developes currents upon precisely the same principles as are employed in the construction of dynamos. In other words, if the sun were to cease rotating there would be no origination and conduction of currents through the agency of induction acting upon surrounding meteoric debris or otherwise, no matter how much eruptive energy might be displayed. But such currents having been originated their propagation in a certain direction exclusively corresponds to what is known generally in regard to the behaviour of such forces. During magnetic storms for example, the telegraph lines in some one direction may be entirely disabled while all others are working freely. Thus induction developes lines of force, temporary poles, attractions and repulsions and the like, which in the case of the sun are simply exhibited upon a grander scale. The principles involved do not differ from those being familiarized in the ordinary commercial applications of magnetism and electricity. The thunderstorm and the aurora are but the flashing of the spark incidental to the charging up and whirling of the great dynamos best known as sun and planets.

The simplest electrometer experiment shows that the atmosphere is constantly electrified. That such electrification is capable of producing motion is shown by the play of air currents about the points of an electrical machine in operation. Such an experiment affords a presumption at least that the same thing may occur on a larger scale in nature. The eastward push of anti-cyclones, and attendant intensification of storms, and the vast re-arrangements of the distribution of pressure both in isolated cases and continuously in series of months and years all occur in such manner and with such surroundings as are consistent with the view that they depend upon these inductive forces and none other. Certainly there can be no heating up of continents or seas in a single day adequate to account for such intensification of barometric conditions and rapidity of movement as often appears.

In years when magnetic forces are at a maximum the belts of sun spots on each side of the solar equator are transferred to higher latitudes, as though the force of induction had reacted upon the sun itself. This corresponds precisely to the coincident change in the location of the belts of anti-cyclones upon the earth due to the same cause, they also being concentric with the magnetic poles rather than with the axis of rotation. Certainly in the case of the sun, this belt-like arrangement and its transference back and forth in latitude cannot be due to any heating up of the equatorial regions from an external source, there being no other sun shining upon our sun competent to produce such effect. That it is the reflux of magnetic induction that creates the spots upon the sun is shown by the fact that they haunt the localities where the eruptive forces concerned in the production of the aurora are most active. Spots not unfrequently increase in size as they reach some particular part of the visible disc as though there were something in that vicinity independent of the sun or at least not moving with it capable of originating them. This something certainly cannot be heat from an external source and the manner of its action is such that it is very unlikely that it is gravitation, or in other words tidal stress, but it is very probable meteoric or planetary matter that has become specially charged as the result of some preceding outbreak which has occurred with such abruptness and force as to have left its impress upon the sub-permanent magnetism of particles in some one direction from the sun, causing a reactionary effect upon the other sections as they pass that point.

The relation of what is known as the eleven year period of sun spots to the perihelions of Jupiter illustrates very clearly the manner in which magnetic induction is originated in the sun and propagated back and forth throughout the solar system in the manner described in the preceding paragraph, It is found that in cycles of one hundred and sixty-six years the perihelions of Jupiter make one complete round of coincidences with all phases of sun-spot activity from maximum to minimum and back again. It follows from this that the perihelion position of Jupiter cannot determine the times of recurrence of any particular phase or degree of solar activity inasmuch as it is coincident in regular order with them all. Just now the perihelions coincide with sun-spot maxima but going backward they gradually recede until about eighty-three years ago they fell almost precisely midway between such maxima and did not again coincide as at present until one hundred and sixty-six years ago. Thus the average sun-spot period is shorter than a revolution of Jupiter in the ratio of fourteen to fifteen. Nor is it possible to explain this shortening by bringing into the account the perihelions of the other planets or their alignments with each other at conjunction or opposition. There is no configuration of planetary positions that coincides with any particular phase of the eleven year period. The proof is very positive that variation in gravitational or tidal stresses is not the cause of the manifest periodicity at this interval. Nor have we evidence of the existence of anything else external to the sun itself capable of producing recurring solar convulsions on so vast a scale. Certainly there is no periodic intrusion into the solar system of meteoric matter adequate to produce so great an effect. If such were the case it is impossible that the earth itself should escape consequent disaster. In short so far as existing knowledge extends we are absolutely shut up to the conclusion that the forces chiefly concerned are wholly internal to the sun itself, and that the eleven year periodicity simply represents what may be termed the co-efficient of solar viscosity. Thus the accumulation and bursting forth of the pent up forces must recur at intervals whose equality with each other depends upon the extent to which the mass of the sun is homogeneous and uniformly coherent. The sun itself being hot does not strictly speaking become a magnet in virtue of these recurring activities, but the turmoil of eruption as in the case of the terrestrial volcano generates electrical currents locally, which in the case of the sun occupy the cooler overlaying portions of the photosphere and which are propagated throughout the solar system in strict conformity to the laws governing magnetic induction particularly as exemplified in the case of rotating bodies. Now it is evident that proximity to the source of induction will increase the effect experienced which will be greater also in proportion to the size of the body thus exposed. Thus Jupiter being the largest planet when nearest the sun receives and transmits a proportionately greater effect. Thus when the perihelions of Jupiter become coincident with the recurring maxima of solar activity all the effects of such activity both direct and indirect are strengthened, the planet in virtue of consequent increase in its sub-permanent magnetism acting like a great storage battery for their accumulation as well as their transmission. Thus there is increased reaction upon the sun itself in the manner indicated in the last paragraph and sun spots become larger than when the perihelions of Jupiter do not coincide with maxima of solar activity. There is in like manner increased reaction upon other members of the solar system, and magnetic storms and auroras on the earth become stronger at such times. As has already been explained, coincidence of the perihelions of Jupiter with maxima of solar activity recur in cycles of about one hundred and sixty-six years and the resultant strengthening of such maxima may be traced backward at corresponding intervals as far as we have any record or for about eighteen hundred years. Evidence of similar action and reaction in respect to the other planets as well as Jupiter has been found, that between the moon and earth being especially well marked in a periodic strengthening of magnetic storms apparently dependant upon the perihelion position of the former in its orbit.

Thus relations to electrical induction come out distinctly in a multitude of ways, and the study of thunderstorms as a practical exemplification of the action of these forces becomes increasingly interesting. The idea based upon certain laboratory experiments which ascribes such storms to the storing up of positive electricity in the upper atmosphere through the evaporation of a saline solution such as are the waters of the ocean, and the discharge of this electricity disruptively in the case of thunderstorms and quietly in the case of auroras is utterly inadequate. If this be the proper explanation there must have been an enormous amount of such evaporation for a curiously limited interval on Feb. 13th, 1892, and exactly twenty-seven and one-quarter days later, it must have begun again in a very strange way in order to account for the world-wide magnetic storms and splendid auroras of those dates. The evaporation theory certainly fails to account for the facts in such a case as this, and is equally deficient as an explanation of widespread outbreaks of thunderstorms.

The atmospheric conditions to which thunderstorms are incidental present peculiarities that require examination in detail. Upon any weather map there appear areas of high barometer termed anti-cyclones, from each of which air currents proceed outward in every direction until they meet the corresponding outflow from adjacent anti-cyclones. In a belt along this line of meeting, storm action is most severe. Here there is conflict of winds, air strata at different altitudes moving in different directions with sudden shifts, and rapid changes of temperature and more or less cloudiness and precipitation. Along this line are eddyings and whirls some of which reach the dimensions of the rotary storms designated cyclones. In the midst of this turmoil, but not at the seat of lowest pressure thunderstorms are most apt to occur. The ordinary theory is that all this atmospheric commotion is due to the agency of heat and gravitation modified somewhat by the deflecting force of the earth's rotation, and that the thunderstorm is generated on the spot and is not due to any form of induction from the sun.

It may prove to be advantageous to examine this theory somewhat in detail. According to this view masses of air warmed by the sun's rays or by condensation of aqueous vapor and liberation of latent heat, as the case may be, are supposed to acquire buoyancy so as to rise in such manner as to permit the air from surrounding localities to gravitate into the place thus made vacant with the velocities and in the directions shown on the weather maps. In order that this theory may be justified, it is necessary that there be evidence of the existence of a vertical column of air ascending with such velocity and to such distance as to correspond with the velocity and extent of the horizontal movement. That is to say, in the case of a cyclonic area of ordinary size, covering a part of New England for example, the upward movement must be on such a scale as would produce a pull on the wind vanes in Chicago very commonly and even in Omaha or Salt Lake City at times. The aspiration of a column of air a thousand miles or more in length against all the irregularities presented by the earth's surface and at velocities of from ten to twenty miles an hour at least, is no small task, and yet the column of air whose vertical movement is supposed to accomplish all this cannot be more than about five miles high, unless it extend beyond the limit of storm action and cloud stratification, which is very improbable. Indeed storms have been noted at the base of Mt. Washington which did not affect the wind direction at the summit. Moreover the very best appliances that have been devised for the measurement of any upward movement of the air, reveal only exceedingly small velocities as compared with those in a horizontal direction.

Again in the case of a very energetic storm remaining almost stationary, like the famous New York blizzard, the indraught and uprush theory assumes that there is a constant abstraction of air from surrounding localities for hundreds of miles at velocities ranging from twenty-five to fifty miles an hour. If all this air is actually drawn into the center of the storm and does not simply circulate around it, it would seem that there should be some indication of such accumulation in that vicinity. The barometer however gives no evidence in such cases of any piling up or massing together of air, not even to such an extent as would account for a gravitational outflow in the upper strata to compensate for the gravitational inflow assumed to exist at the surface of the earth. On the contrary, the harder the wind blows and the more swiftly the storm rotates the lower the pressure at the center, showing that instead of there being any increase in the weight of the total air column or any choking backward due to accumulation of air above there is exactly the opposite. This being the case it is difficult to see how the horizontal component of motion can be gravitation.

There is difficulty also in reconciling the movement upward or downward in cyclones and anti-cyclones with the accompanying distribution of heat. The air overlying centers of low barometer has been found to be very much colder than the normal for corresponding altitudes. There appears to be a dip downward of a stratum of very cold air instead of the projection upward of warm air. The limits of this cold are sharply defined and do not shade off gradually as would be the case if it were cooling due to the expansion of a rising column of air from which the pressure is being moved. In the case of thunderstorms which have been held to be typical examples of the indraught and uprush idea, the projection downward of cold air is so extreme that it reaches the surface of the earth and presents so sharp a margin that the temperature commonly falls fifteen or twenty degrees in two or three minutes as the storm breaks and rises again as it passes away. Moreover in such storms the wind at the surface of the earth blows briskly outward in every direction as well as that of the storm's advance, which is the very reverse of an indraught. This has been noticed even when there has been little or no precipitation, so that the projection downward cannot be due to entanglement with rain drops. Indeed the rain itself not unfrequently appears to be upborne and whirled along by the gust, and it is precisely in those storms where the downpour is heaviest that the lines of descent of the rain drops are most nearly vertical and there is no gust at all. In like manner in the case of a waterspout which came aboard of a ship there was found to be snow at its center, so that here also there must have been a very decided dipping downward of cold air. In view of facts such as these it is difficult to see how the vertical component of motion in cyclones can be heat.

So likewise in the case of anti-cyclones the temperatures at different altitudes do not account for the direction of movement. The writer has made a list of instances in which the temperature on Mt. Washington was higher than at surrounding stations at lower levels, from which it appears that as a rule this happens during the passage of centers of high barometer. Thus the out-flowing air currents from such centers are compelled to derive their supply from the descent of masses of air relatively warmer than that at the surface of the earth. Such air being warmer ought not to descend at all, or if compelled to descend in virtue of the general circulation of the atmosphere, it ought to be warmed in the process by virtue of increasing compression by superincumbent air strata as it reaches lower levels. But instead of becoming warmer it becomes colder. Thus in the case of anti-cyclones also it is difficult to see how the vertical component of motion can depend upon temperature.

Again air leaving centers of high barometer or approaching centers of low barometer does not advance in a radial direction, but makes a fairly constant angle with that direction. Thus the wind vanes are always oblique to the isobars. This so far as is known to the writer has uniformly been ascribed to the deflecting force of the earth's rotation. But when an attempt has been made to secure a numerical value for this deflection the discrepancy between the answers obtained from different sources has been very large. No two have agreed with each other, and not one has given a value corresponding to the angle which the wind arrows make with the isobars. As a matter of fact, this angle on an average corresponds to a departure of about eighty miles for every hundred miles advance in a radial direction. It would seem that if the deflecting force of the earth's rotation were capable of producing a deviation so great as this, to say nothing of the sharper whirl apparent in the tornado, something of the sort should be apparent elsewhere, as for instance in the case of projectiles. But no marksman thinks of making any allowance whatever for the deflecting force of the earth's rotation, not even to the extent of a single foot, to say nothing of any such amount as eighty feet for every hundred that the mark is distant, which is what would be required in order to correspond with the ordinary ratio of wind deviation.

Thus at many points there are serious difficulties in reconciling current ideas in regard to the forces concerned in atmospheric movements with observed facts. The question arises as to whether some important factor has not been omitted and whether a better explanation is not possible. As has been pointed out there is positive evidence that electrical and magnetic impulses of direct solar origin are concerned in atmospheric control. From this point of view the cyclonic and anti-cyclonic wind spirals are referable not to the deflecting force of the earth's rotation, but to the passage between the earth and its surroundings of electrical currents, the air particles in consequence being arranged in the precise manner that appears in the ordinary laboratory experiment in which iron filings are disposed in spirals on a card pierced by a wire through which a current is passing. So too the stratification of masses of air of different temperatures in a manner contrary to gravitation presents no great difficulty, it being due to electrical attractions and repulsions which are competent to antagonize gravitation in the manner actually encountered in these cases. From this point of view also the disproportion between the horizontal and vertical movements which has been pointed out does not present any difficulty, electrical attractions and repulsions and not the buoyancy of the air being the prime motor. In like manner the perpetuation of vertical motion and continuance of centers of low barometer become possible in spite of the tendency of gravitation to cause their cessation by filling up. So too the general eastward push of anti-cyclones and the change of type of weather in different years, and even the diurnal ebb and flow of barometric pressure best seen in the tropics, all occur in such relations and with such concomitants and regular order of sequence as are consistent with the idea that they are due to inductive forces, originated and propagated in the manner that has been indicated and bearing but little if any relation to variability of the sun's power of heat emission.

These views have resulted not from theoretical considerations, but from attempts to classify the phenomena in question in conformity with their most obvious relations. Not only the categories of time and place but also the intimate nature of the phenomena themselves have been considered. In other words it is not a question of mere coincidence, an adequate underlying principle, namely that of induction, being everywhere apparent. In tracing out the ramifications of this principle it is possible that there may have been mistakes of detail. Nor is it claimed that the research is anywhere near complete even in respect to essential features. The purpose of the present discussion will have been accomplished if it shall have been made logically impossible for any one to pretend to have made an adequate study of the thunderstorm or aurora without having taken into the account the relations here pointed out.

The paper was discussed by MR. J. E. PUTNAM.

MAY 23, 1892.

STATED MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

A large audience present.

PROFESSOR CHARLES WRIGHT DODGE, gave the fifth lecture of the Popular Lecture Course, on

THE YEAST PLANT; ITS STRUCTURE AND PHYSIOLOGY.

The lecture was illustrated by charts, microscopes and experiments.

JUNE 13, 1892.

STATED BUSINESS MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

The Council report recommended :

(1.) The payment of certain bills.

(2.) The election of the following persons as active members :

MR. GEORGE D. HALE,
MR. SAMUEL SLOAN,
MRS. SAMUEL SLOAN,
HON. DONALD MCNAUGHTON,
MRS. J. W. OOTHOUT,
MRS. HENRY G. DANFORTH.

(3.) That the Academy hold a meeting in August complimentary to the American Association for the Advancement of Science.

The bills were ordered paid and the members elected by formal ballot. It was voted to hold a midsummer meeting.

The following candidates for fellowship, nominated May 9th, were elected fellows by a formal ballot :

MR. JOSEPH B. FULLER,
MR. E. H. GRIFFITH,
MR. A. M. DUMOND,
PRESIDENT DAVID J. HILL,
DR. P. MAX FOSHAY.

The President announced that in pursuance of notice given May 9, an election for Secretary would now be held.

DR. P. MAX FOSHAY was elected Secretary by formal ballot.

Under a suspension of the rules, the following candidates for membership, nominated at this meeting, were elected members by ballot :

COL. N. P. POND,
MRS. N. P. POND,
MRS. JOHN VAN VOORHIS,
MRS. CORNELIA WARING,
MISS MARGARET MORTON,
DR. PAULINE MORTON.

June 27, 1892.

STATED MEETING.

The President, Professor H. L. Fairchild, in the chair.

Nineteen persons present.

In the absence of the Secretary, Mr. J. M. Davison was appointed Secretary pro-tem.

The Curator of Botany, Miss Florence Beckwith, announced that Mr. Gilbert Van Ingen had presented 170 specimens of plants to the Herbarium of the Academy.

Professor S. A. Ellis, of the committee to draft resolutions on the death of our late member Mr. Robert Bunker, made the following report:

Rochester, N. Y., June 27, 1892.

To the Rochester Academy of Science, Prof. H. L. Fairchild, Pres't.

Dear Sir:—Your committee, appointed to present a memorial of the late Robert Bunker, beg leave to submit the following:

Robert Bunker, son of Laban and Deborah Bunker, was born in Ghent, Columbia Co., N. Y., November 20th, 1820. At the age of seven years, he removed with his parents to this city, where he died March 6th, 1892.

He attended the common schools until the age of fourteen or fifteen, when he entered his father's shop, to learn the trade of a cooper.

It was at this time, that he developed a taste for Entomology and began collecting and rearing butterflies and moths. While pursuing his studies and experiments in Entomology, he took up the study of the microscope and acquired considerable skill in the use of that instrument.

He was a charter member of the Rochester Academy of Science and President of the Entomological section of the Society.

Soon after the re-organization of the Academy of Science, he presented to it the entomological collection, which bears his name. A special feature of the collection, is the large number and variety of moths it contains.

Mr. Bunker was a man of decided literary taste, and his contributions to the "Canadian Entomologist," "Vick's Magazine" and other scientific publications, show him to have been an acute and intelligent observer of insect life.

He had considerable correspondence with entomologists abroad with whom he effected some valuable exchanges.

The "Entomological News" says of him: "He was personally a man of strong traits of character, upright and honorable in every relation of life; broad minded yet positive in his opinions; genial and courteous in his intercourse with friends and neighbors,"—in which we heartily concur.

His death is sincerely mourned by his entomological friends, by the members of this Academy and by this community, among whom, more than three score years of his life was spent. Mr. Bunker was married May 21st, 1854, to Miss Jane E. Bills, of Clarkson, N. Y., who survives him.

Respectfully submitted,

S. A. Ellis,
Wm. Streeter,
James W. Allis,
Committee.

The following paper was then read:

PRELIMINARY NOTE OF A NEW METEORITE FROM KENTON COUNTY, KENTUCKY,

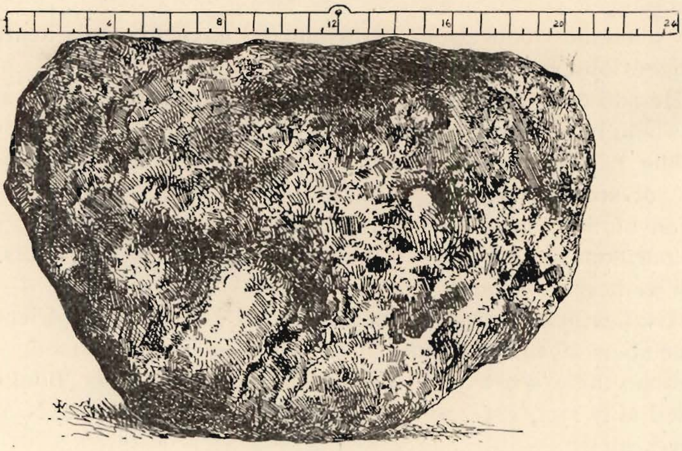
By H. L. Preston.

On May 15th, Professor Henry A. Ward received a letter from Mr. R. H. Fitzhugh, Bryson City, N. C., telling of a meteorite he had identified in Kenton County, Kentucky.

In Professor Ward's absence Mr. Frank A. Ward started me off the same night to look up the meteorite.

I arrived at Bracht station on the Cincinnati Southern R. R. Friday morning and drove as far as the roads would permit toward Mr. Geo. W. Cornelius' farm. He being away from home, his wife showed me the "metal" as they called it, and it proved to be a beautiful meteorite of the siderite variety, 533 x 356 x 203 millimeters (21 x 14 x 8 inches) in its greatest diameters, and weighed 163.0665 kilograms (359½ pounds.)

In form in certain directions it very much resembles a nautilus, and has numerous but mostly shallow pittings, a few deep pittings occurring however on the side shown in the accompanying cut, which gives a good idea of the general outlines of the meteorite.



1-7 NATURAL SIZE.

This meteorite is entirely free from crust.

I saw Mr. Cornelius on the evening of the next day and obtained from him the following facts in relation to the meteorite.

About the middle of August, 1889, while cleaning out a spring situated at the head of a gully some three-quarters of a mile from his present home in Kenton County, eight miles south of Independence, the county seat, he struck with his hoe something that had a metallic ring: obtaining assistance he took the mass out, finding that it was interlocked in the roots of an ash tree from thirteen to fourteen inches in diameter, and was between three and four feet below the normal surface.

He let the mass lie by the spring until August, 1890, when he removed it to his woodshed, where it has lain until purchased by me for the Ward collection of meteorites and it is now at our establishment in Rochester, N. Y.

For the following analysis of this meteorite I am indebted to Mr. Davison.

Analysis of Kenton County Kentucky Meteorite :

Fe	91.59
Ni	7.65
Co	.84
Cu	trace.
C	.12
S	trace.
P	trace.
	100.20

JOHN M. DAVISON,
Reynolds' Laboratory, University of Rochester.

In the course of a conversation with Mr. S. J. Cornelius, a brother of the gentleman of whom I purchased the meteorite, he mentioned the fact, that about three o'clock on the seventh of July, 1873, while returning from a picnic in this locality, and when within a half mile of where the metorite was subsequently found, he heard a great rumbling in the heavens, which appeared to last three or four minutes and was followed by a quivering of the earth. As the day was clear he could not account for this phenomena. I met at least seven other people who distinctly remembered the picnic and the "rumbling in the heavens," and some one or two the "quiver in the earth."

(Is there any connection between this date and the fall of this meteor?)

Mr. Preston also read extracts from a publication by the British Museum on the history of meteorites and theories as to their origin. He exhibited a cast of the new meteorite and sections of typical metallic, stony and mixed meteorites, showing the Widemanstätten figures, nodules, troilite, pittings, and crust characteristic of these bodies.

An interesting exhibit was that of a cast of a meteorite now in the British Museum. This is in three pieces, a large and two smaller ones and the fragments were found many miles apart, but so fitting together as to make it evident that they were once united. One of the smaller fragments is entirely encrusted, showing that it had been torn from the mass early in its flight while its velocity was still such as with the resistance of the air to raise the surface of the mass to the melting point. The other small fragment thrown off as the body neared the earth, is also encrusted save at the place of separation from the parent mass where the surface is unfused and fresh, showing that, when it parted, the steady resistance of the air had so checked its speed that fusion was no longer possible. So with the fires of youth quenched and an independent career denied it, it settled upon the shelves of the Museum by the side of its more brilliant brother, by a happy law of compensation serving as useful and honorable an end.

The President exhibited photographs showing pitting made by tadpoles in the muddy bed of the old canal, and a laminated rock with bullæ made when it was plastic by imprisoned marsh gas—the reverse side bearing a strong resemblance to the work of the tadpoles in the canal mud.

The following paper was read by title :

HYMENOMYCETEÆ OF ORLEANS COUNTY, N. Y.,

BY DR. CHARLES E. FAIRMAN.

The following Hymenomyceteæ or Fleshy Fungi, comprising Mushrooms, Toadstools, Shelf Fungi and allied forms were mostly collected at Lyndonville, N. Y. I have given the reference to the Reports of Professor PECK when I have found that the species under consideration had been previously listed in the Reports, so far as I have been able to discover. The species listed number 126. In my paper on Fungi of Western New York in Proceedings of the Rochester Academy of Science, Vol. I, Aug., 1890, the number of Hymenomyceteæ was given as 96. The number has been brought up to 126 by subsequent collections.

FUNGACEÆ.

I. FUNGI SUPERIORES.

HYMENOMYCETEÆ.

Fam. 1. AGARICINEÆ.

Sect. 1. LEUCOSPORÆ.

AMANITA Pers.

1. **Amanita pantherina** D'C. Peck Bull. N. Y. S. M. Vol. I. No. 2, page 25. Panther mushroom.

Thin dry woods and maple groves. Lyndonville, Aug., Sept.

2. **Amanita nivalis** Peck. 33d Rep. Snow white Amanita. Woods. Lyndonville, Sept., 1889.

The European mycologists consider *A. nivalis*, Grev. to be only a white variety of *A vaginata*, Bull. We have both forms in this country and they are probably distinct. If the European mycologists are correct in their identification of Greville's plant then our plant will stand as *Amanita nivalis*, Peck, not of Greville.

3. **Amanita phalloides** Fr. Pk. 23 Rep., p. 69. Phallus-like Amanita. Woods. Lyndonville, July, 1890.

LEPIOTA Fr.

4. **Lepiota procera** Scop. Pk. 23 Rep., p. 71, 35 Rep., p. 152. Parasol mushroom. Common in woods, pastures, and by roadsides. July, Oct. Lyndonville.

5. **Lepiota cristata** A. and S. Pk. 35 Rep., p. 155. Crested Lepiota. On lawns. Lyndonville. Aug., Sept.

ARMILLARIA Fr.

6. **Armillaria mellea** Vahl. Pk. 23 Rep., p. 73, 24 Rep., p. 102, 33 Rep., p. 36. Honey colored mushroom. On ground in woods on Lake Shore, Yates. Sept., 1886.

TRICHOLOMA Fr.

7. **Tricholoma alba** Schaeff. Pk. 35 Rep., p. 131, 44 Rep p. 57. White Agaric. Greenman's woods, Yates, July, 1886.

CLITOCYBE Fr.

8. **Clitocybe laccata** Scop. Pk., 23 Rep., p. 77. Woods, Ridgeway.

9. **Clitocybe nebularis** Batsch. Pk. 23 Rep., p. 76. Clouded Clitocybe. Ours is the small and pale form. Lyndonville, June, 1889.

COLLYBIA Fr.

10. **Collybia Leaiana** Berk. Pk. 38 Rep., p. 109. Lea's Collybia. On rotting logs in woods. Ridgeway, May, 1886.

11. **Collybia dryophila** Bull. Pk. 23 Rep., p. 69. Oak-loving Collybia. Woods, Ridgeway, Spring, Autumn.

12. **Collybia radicata** Relh. Pk. 23 Rep., p. 79, 31 Rep., p. 54. Rooted mushroom. Very common in woods and pastures. Yates and Ridgeway. Easily recognized by its tail-like fusiform root.

MYCENA Fr.

13. **Mycena galericulata** Scop. Pk. 23 Rep., p. 81, 26 Rep., p. 90. Peaked Mycena. On rotten stumps. Yates, Orleans Co., May, 1886.

OMPHALIA Fr.

14. **Omphalia campanella** Batsch. Pk. 23 Rep., p. 85. Bell-shaped mushroom. Edge of woods. Lyndonville, June–Sept.

PLEUROTUS Fr.

15. **Pleurotus ostreatus** Jacq. Pk. 22 Rep., p. 77. Oyster mushroom. On trunks of willow trees. County Line road, North Ridgeway. Not common. Nov., 1885.

16. **Pleurotus striatulus** Fr. Pk. 30 Rep., p. 39. Striate Pleurotus. On fallen maple and elm branches. Yates, Orleans Co., March, 1886. Very small and easily overlooked.

17. **Pleurotus sapidus** Kalchb. Pk. 29 Rep. p. 38. Ridgeway. Common in woods. Generally caespitose. Spring to Autumn.

18. **Pleurotus septicus** Fr. Pk. 31 Rep., p. 32. Septic Pleurotus. On rotten wood. Yates, Orleans Co., April, 1888.

19. **Pleurotus pubescens** Peck. Pk. 44 Rep., p. 18. Downy Pleurotus. Ridgeway, N. Y., Aug. Described by Peck from specimens found growing on trunks of standing trees, and was the only new species of Agaric collected by the author in Orleans County. It grew sub-caespitose.

HYGROPHORUS Fr.

20. **Hygrophorus luridus** (doubtful). Edge of thin woods, Yates, Orleans Co.

21. **Hygrophorus Cantharellus** Schw. Pk. 23 Rep., p. 114. Chantarelle Hygrophorus. Swamps. Lyndonville, July.

22. **Hygrophorus borealis** Peck. Pk. 26 Rep., p. 64. Damp shaded places in woods. Lyndonville, Sept.

LACTARIUS Fr.

23. **Lactarius trivialis** Fr. Peck N. Y. Species of Lactarius, 38 Rep., p. 120. Woods, Lyndonville, July, 1889. Common Lactarius.

24. **Lactarius fuliginosus** Fr. Peck N. Y. species of Lactarius, 38 Rep., p. 128. Smoky or dingy Lactarius. Edge of thin woods, Lyndonville, July and August.

25. **Lactarius cinereus** Peck. Peck N. Y. Species of Lactarius, 38 Rep., p. 122. Cinereous Lactarius. Woods, Yates, Orleans Co., August.

26. **Lactarius camphoratus** Fr. Peck N. Y. Species Lactarius, p. 132, Rep. 38. Camphor Lactarius. Swamps, Lyndonville, July and August.

27. **Lactarius glyciosmus** Fr. Peck N. Y. Species of Lactarius, 38 Rep., p. 123. Fragrant or Scented Lactarius. Edge of woods, Lyndonville, September.

RUSSULA Pers.

28. **Russula purpurina** Q. and S. Pk. 42 Rep., p. 24. Purple Russula. Thin woods, Ridgeway, Orleans County. A beautiful plant. Peck found it in mossy ground in woods of balsam. It occurs

with us under beech and maple trees. Rare and only reported from one other locality in United States.

CANTHARELLUS Adans.

29. **Cantharellus cibarius** Fr. Peck N. Y. Species of Cantharellus, Bull. N. Y. State Mus., Vol. I, No. 2, page 38. Edible Chantarelle. Woods Ridgeway and Yates, Orleans Co., N. Y., July to September.

30. **Cantharellus infundibuliformis** Scop. Peck N. Y. Species Canth., Bull. N. Y. S. M., Vol. 1, No. 2, page 41. Funnel shaped Chantarelle. Woods Lyndonville, July to Oct. Common.

31. **Cantharellus aurantiacus** Fr. Peck N. Y. Species Canth. l. c., page 35. Orange Chantarelle. False Chantarelle. Edge of swamps and woods, Lyndonville, Aug., Sept.

32. **Cantharellus floccosus** Schw. Peck N. Y. Species Canth. loc. cit., page 37. Floccose Chantarelle. Borders of woods, Lyndonville, Sept.

MARASMIUS Fr.

33. **Marasmius rotula** Fr. Pk. 23 Rep., p. 125. On dead twigs. Common. Spring to Autumn, Lyndonville.

34. **Marasmius siccus** Schw. Pk. 23 Rep., p. 126. Dry Marasmius. In wet marshes, Lyndonville, July. Our specimens are the small form and the same as *M. campanulatus* Peck, which should be considered a synonym of *M. siccus* Schw.

35. **Marasmius anomalus** Peck. Pk. 24 Rep., p. 76. On sticks in woods, Yates, Orleans Co. Not common. Aug.

36. **Marasmius glabellus** Peck. Pk. 26 Rep., p. 66. On leaves and twigs in woods, Lyndonville. Aug.

LENTINUS Fr.

37. **Lentinus lepideus** Fr. Pk. 23 Rep., p. 126. Scaly Lentinus. On railroad ties on R., W. and O. R. R., near Millers, N. Y. July. Rare.

38. **Lentinus strigosus** Schw. On logs in woods. Lyndonville.

PANUS Fr.

39. **Panus stipticus** Fr. Pk. 33 Rep., p. 36. Astringent Panus. Common everywhere on stumps, etc.

Lenzites Fr.

40. **Lenzites betulina** Fr. Pk. 33 Rep., p. 36. Birch Lenzites. Common on logs, stumps, etc.

41. **Lenzites sepiaria** Fr. Pk. 35 Rep., p. 146. Hedge or Fence Lenzites. Abnormal resupinate form, found on old horse blocks, at North Ridgeway, N. Y.

42. **Lenzites corrugata** Klotzsch. Wrinkled Lenzites. On dead willows in marsh, Lyndonville, April, 1888.

43. **Lenzites crataegi** Berk. Hawthorn Lenzites. On dead cornus trees, marshes, Lyndonville.

Schizophyllum Fr.

44. **Schizophyllum commune** Fr. Pk. 22 Rep., p. 81. Common on old stumps everywhere. Also a form which agrees well with the description of Var. *palmatum* Debeaux, Sacc. Syll., Vol. IX, p. 81, was found at Lyndonville on old apple tree stumps.

Sect. 2. RHODOSPORÆ.

Pluteus Fr.

45. **Pluteus cervinus** Schæff. Peck N. Y. Species of Pluteus, 38 Rep , p. 134. Fawn colored Agaric. On stumps in woods, not common. Somerset, May, 1886.

Sect. 3. OCHROSPORÆ.

Pholiota Fr.

46. **Pholiota adiposa** Fr. Pk. 23 Rep., p. 90. Stout or obese Pholiota. On logs in woods, Lyndonville, June, 1886.

47. **Pholiota marginata** Batsch. Margined Pholiota. Woods Lyndonville. This fungus is a variable one and is deceiving because the annulus is often slight and evanescent.

48. **Pholiota praecox** Pers. Early Agaric. Early Pholiota. Lawns and pastures, Lyndonville.

Inocybe Fr.

49. **Inocybe geophylla** Sow. Pk. 26 Rep., p. 90. On the ground in woods, Lyndonville.

50. **Inocybe lanuginosa** Bull. Hab. same as preceding.

FLAMMULA Fr.

51. **Flammula sapinea** Fr. Pk. 32 Rep., p. 29. Pine Flammula. On trees in woods, Lyndonville.

NAUCORIA Fr.

52. **Naucoria semiorbicularis** Bull. Pk. 23 Rep., p. 93. Half-round Naucoria. Very common on lawns, Lyndonville, June to September. When young the pileus is viscid. May be distinguished from *Stropharia semiglobata*, Batsch, by not having a ring or annulus on the stem.

CREPIDOTUS Fr.

53. **Crepidotus dorsalis** Peck. Pk. 24 Rep., p. 69. On logs, Lyndonville, July, 1886.

Sect. 4. MELANOSPORÆ.

AGARICUS Linn.

54. **Agaricus campestris** Linn. Pk. 23 Rep., p. 97. Common Mushroom. On flats along Johnsons Creek, Yates, Orleans Co., and meadows, Ridgeway, N. Y., Sept. and Oct.

55. **Agaricus placomyces** Peck. Pk. 29 Rep., p. 40. On lawns under shade trees, Lyndonville, N. Y., Aug , Sept.

STROPHARIA Fr.

56. **Stropharia semiglobata** Batsch. Pk. 23 Rep., p. 98. Hemispherical Mushroom. Common on dung by roadsides.

HYPHOLOMA Fr.

57. **Hypholoma sublateritium** Schæff. Pk. 22 Rep., p. 78. Brick colored Hypholoma. We have the typical form and also var. *perplexum*, Peck. On lawns and edge of woods. Lyndonville, Aug., Sept.

COPRINUS Pers.

58. **Coprinus micaceus** Fr. Pk. 23 Rep., p. 104. Roadsides, Lyndonville, June to Aug.

59. **Coprinus plicatilis** Fr. Pk. 23 Rep., p. 104. On rich lawns, Lyndonville, May.

60. **Coprinus ephemerus** Fr. Pk. 23 Rep., p. 105. On manure piles, Lyndonville, May.

61. **Coprinus picaceus** Fr. var. *ebulbosus* Pk. Peck 44 Rep., p. 20. The original specimens were found growing upon a log in damp shaded woods, Lyndonville. Distinguished by the absence of a bulb.

62. **Coprinus fimetarius** Fr. Common on dunghills. Lyndonville.

PANÆOLUS Fr.

63. **Panæolus solidipes** Peck. Pk. 23 Rep., p. 101. On manure heaps, Lyndonville, June to September. Noteworthy from being more substantial than most of the fimicolous Agarics.

64. **Panæolus campanulatus** L. Pk. 23 Rep., p. 102. Hab. as in 63. Lyndonville, June–Sept.

Family 2. POLYPOREÆ Fr.

BOLETUS Dill.

Viscipelles.

65. **Boletus piperatus** Bull. Peck Boleti of U. S. Bull N. Y. S. M. No. 8, page 102. Peppery Boletus. Woods, Lyndonville.

Subpruinosi.

66. **Boletus pallidus** Frost. Peck Boleti of U. S. loc. cit. p. 113. Pale Boletus. Woods, Lyndonville.

Subtomentosi.

67. **Boletus chrysenteron** Fr. Peck Boleti of U. S. loc. cit. page 116. Red-cracked Boletus. Woods, Lyndonville and Ridgeway. Common. Known by the red streaks in the cracks of the pileus.

68. **Boletus sulphureus** Fr. Sulphur Boletus. Lyndonville.

Edules.

69. **Boletus variipes** Peck. Pk. Boleti U. S. loc. cit. page 133. Variable Stemmed Boletus. Woods, Lyndonville.

Hyporhodii.

70. **Boletus felleus** Bull. Pk. Boleti U. S. l. c., page 154. Bitter Boletus. Edge of Woods, Lyndonville and Ridgeway.

Cariosi.

71. **Boletus cyanescens** Bull. Pk. Boleti U. S. l. c., p. 156.

Bluing Boletus. Yates and Ridgeway, Orleans Co. Wounds of the flesh turn instantly blue.

BOLETINUS Kalchbr.

72. **Boletinus porosus** Peck var. opacus. Pk. Boleti U. S. loc. cit. Eccentric Stemmed Boletinus. Woods, Somerset, Niagara Co., N.Y.

POLYPORUS Fr.

73. **Polyporus abietinus** Fr. Pk. 22 Rep., p. 84. Fir Polyporus. Common on hemlock logs, Lyndonville.

74. **Polyporus applanatus** Fr. Pk. 22 Rep., p. 83. Flattened Polyporus. Common on trunks of trees and fallen logs. Woods, Yates, Carlton, Ridgeway, Orleans County.

75. **Polyporus biformis.** Klotzsch, Linn. VIII, p. 486. Pk. 22 Rep., p. 83. Not common. Hab. not recorded.

76. **Polyporus brumalis** Fr. Pk. 22 rep., p. 82. Winter Polyporus. On stumps of *Ailanthus glandulosus* L., and on sticks on ground in woods. Yates, Orleans Co.

77. **Polyporus cæruleoporus** Peck. Pk. 26 Rep., p. 68, 32 Rep., p. 57. On ground in woods under hemlock trees. Lyndonville.

78. **Polyporus cinnabarinus** Fr. Pk. 22 Rep., p. 83. Cinnabar Polyporus. On old cherry tree branches. Ridgeway and Yates.

79. **Polyporus conchatus** Fr. Shell-shaped Polyporus. Resupinate form. Lyndonville.

80. **Polyporus elegans** Fr. Pk. 25 Rep., p. 109. On decaying logs in woods. Yates, Orleans Co.

81. **Polyporus fomentarius** Fr. Pk. 22 Rep., p. 82. On stumps and logs. Ridgeway. Not common.

82. **Polyporus griseus** Peck. Pk. 26 Rep., p. 68. Peck's Grey Polyporus. On ground in woods under hemlock trees. July, 1889, Lyndonville.

83. **Polyporus hirsutus** Fr. Pk. 22 Rep., p. 83. On dead trunks of trees. Hairy Polyporus. Common.

84. **Polyporus lucidus** Fr. Pk. 22 Rep., p. 82, 34 Rep., p. 57. Shining Polyporus. Varnished-stem Polyporus. Common in woods about old hemlock stumps. Lyndonville, Ridgeway.

85. **Polyporus perennis** Fr. Pk. 22 Rep., p. 82. On ground in woods. Lyndonville.

86. **Polyporus pubescens** Fr. On old stumps in woods. Not common. Lyndonville. Downy Polyporus.

87. **Polyporus sulphureus** Fr. On trunks of dead trees and stumps. Lyndonville. Sulphur Polyporus. Often forms large masses.

88. **Polyporus Vaillantii** Fr. Pk. 24 Rep., p. 79. Vaillants Polyporus. On twigs and logs. Uncommon and variable. Lyndonville, Ridgeway.

89. **Polyporus versicolor** Fr. Pk. 22 Rep., p. 84. Changeable Polyporus. On dead stumps. Common. Lyndonville, Carlton, Ridgeway, Orleans County.

MUCRONOPORUS Ellis and Everhart.

90. **Mucronoporus ignarius** (Fr.) E. and E. Pol. ignarius Fr. in Pk. 33 Rep., p. 36. Ridgeway, Orleans County.

91. **Mucronoporus ferruginosus** (Schrad.) E. and E. *P. ferroginosus* in Pk. 26 Rep., p. 70. Resupinate form on limbs of trees. Yates, Orleans Co.

PORIA Fr.

92. **Poria contigua** Fr. Under-side of rails on ground. Lake Shore, Yates, Orleans Co.

93. **Poria obducens** Pers. Pk. 30 Rep., p. 46. Hab. same as No. 92.

TRAMETES Fr.

94. **Trametes mollis** Fr. On dead branches in woods. Rare. Lyndonville.

DÆDALEA Pers.

95. **Dædalea Unicolor** Fr. Common on stumps, etc. Yates and Ridgeway, Orleans Co.

FAVOLUS Fr.

96. **Favolus alveolarius** (D C). Common on fallen branches, especially of Carya species.

American Mycologists are at variance in regard to the proper specific name of this fungus. In Bulletin Iowa Agric. Coll. Nov. 1884, p. 147 and Ellis N. A. F., No. 604, it is referred to *Favolus Europæus* Fr. While Morgan in Mycol. Flora Miami Valley refers it to *Favolus Canadensis* Klotzsch. The plant deserves therefore more than a passing reference. Stevenson (British Fungi, Vol. 2, page 227) gives the following description of the Genus :

" Favolus (favus-honeycomb) Fr. Elench, p. 44, Hymenium reticulate, cellular or alveolate. Alveoli radiating, formed of the densely anastomosing gills, elongated. Spores white (in pairs ?). Dimidiate, somewhat stipitate, fleshy, pliant. Annual, growing on wood, differing in entire appearance and structure from the preceding genera, wherefore they were formerly referred not to Polypori but to Cantharelli or Merulii, Fr. Hym. Eur., p. 590."

In Mycologic Flora Miami Valley, April, 1886, p. 5, Morgan describes our species and gives the following notes concerning it:

"*Favolus Canadensis* Klotzsch."

"Pileus fleshy tough, thin, reniform, fibrillose scaly and tawny, becoming pale and glabrous. Stipe eccentric or lateral, very short or obsolete. Alveoli angular, elongated, whitish; the dissepiments becoming thin, rigid and dentate, spores oblong, .012 by .007 m. m.

"In woods on fallen branches, especially of hickory. Common. Pileus 1–2½ inches in breadth, sessile or with a very short stipe. Specimens with an excentric stipe resemble *Polyporus lentus* Berk., but the pores are much larger than those of that species. This is undoubtedly the *Polyporus Boucheanus* Kl. of Lea's Catalogue, as is confirmed in the notices of Berkeley under No. 44; but Fries in the Novæ Symbolæ seems to indicate that these American forms are not his species and certainly the description in the Epicrisis does not apply to our plant. Specimens from New England gathered by me are glabrous or scantily fibrillose, and may be the *F. Alutaceus* B. and Mont.: they are no doubt what is meant by *Polyporus Boucheanus* Var. *peponinus* B. and C. in the Notices of N. A. Fungi under No. 44. The original description of Klotzsch was based upon a single specimen in the herbarium of Hooker, and it applies remarkably well to our plant, except that the pileus is sometimes lobed as in *F. Alutaceus* B. and Mont."

At this point it is interesting to compare the characters assigned in Epicrisis to the species mentioned, which are subjoined:

FAVOLUS EUROPÆUS.

"Pileo carnoso-lento tenui *orbiculari glabro* lævi albido, stipite brevi laterali, alveolis profundis subrotundis reticulatis. Merulius Alveolarius Dec. Fr. 5, p. 43. S. M., p. 322. In Gallia meridionali."

FAVOLUS CANADENSIS.

"Pileo carnoso-lento rigente reniformi *squamoso fulvo*, stipite obsoleto, alveolis elongatis tenuibus albidis, Klotzsch in Linn. VII, p. 197. In Canada."

POLYPORUS BOUCHEANUS.

"Pileo carnoso-lento, plano inæquali *lævi dein squamoso,* gilvo, stipite excentrico curto *tomentoso* deorsum fuscente, poris tenuibus demum *alveolaribus* oblongo hexagonis dentatis dilute aurantiacis, Klotzsch in Linn., VIII, p. 316. Ad truncos Betulæ Cfr. Favolus, cui adscripsit Klotzsch."

Mr. J. B. Ellis in lit., March 9, 1888, says: "I have specimens of Favolus from various parts of the U. S. and Canada, and they all seem to me to be the same thing, and Cooke, Saccardo and Winter, to whom I have sent specimens, all call it *Favolus Europaeus*, Fr. I suspect that F. *Canadensis* Klotzsch is the same thing, but I do not absolutely know it to be so." On the other side Professor Charles H. Peck writes me under date of Feb. 14, 1888: "We have two or three forms which have been referred by various persons sometimes to *F. Europæus or F. Canadensis*, and sometimes to *Polyporus Boucheanus.* One I think is *F. Canadensis* Kl., as does also Morgan. Kalchbrenner when living also took the same view."

Mr. John Macoun, Botanist of Canadian Geological and Natural History Survey, wrote me April 23, 1889, from Bunad Inlet, B. C.: "I collect two species of Favolus, one of them being *F. Canadensis.* As far as I am aware none grow on this coast." After a number of years of observation of the variety of forms which Favolus assumes as it grows here, and after comparison of specimens from other localities labelled Canadensis and Europæus I am unable to find any good characters to separate them. It is probable that the forms run together. I believe that the tawny variety often becomes bleached by exposure to the weather, and as a result we have a paler and glabrous form. Nor can I detect constant histological differences. The species is considered to be the same as *Merulius alveolarius* published by De Candolle in Flore Francais (from 1805 to 1815). *Favolus Europæus* was published in Fr. Epicrisis, 1836–1838. Hence I have restored the specific name alveolarius and call our specimens *Favolus alveolarius* (D. C.)

GLŒOPORUS Mont.

97. **Glœoporus conchoides** Mont. Pk. 30 Rep., p. 75. This is considered to be the same as *Polyporus nigropurpurascens* Schw. On fallen logs in woods. Yates, Orleans Co., March, 1886.

SOLENIA Hoffm.

98. **Solenia ochracea** Hoffm. Pk. 25 Rep., p. 83. Occurs

abundantly upon fallen branches of various species of Salix, Cornus, Tilia, etc., in woods, Lyndonville.

Family 3. HYDNEÆ Fr.

Hydnum L.

99. **Hydnum coralloides** Scop. Common on logs and branches in moist woods.

100. **Hydnum versipelle** Fr. Woods, Somerset, Niagara Co.

101. **Hydnum rufescens** Pers. In woods. Regarded by Fries as a variety of Hydnum repandens.

Irpex Fr.

102. **Irpex sinuosus** Fr. Pk. 30 Rep., p. 46. On dead twigs and branches, woods, Lyndonville.

103. **Irpex obliquus** Fr. Pk. 30 Rep., p. 46. Hab. same as preceding.

Grandinia Fr.

104. **Grandinia granulosa** Fr. In woods on fallen branches. April, Lyndonville.

Odontia Pers.

105. **Odontia fimbriata** Pers. Pk. 24 Rep., p. 80. On Maple bark, Yates, Orleans Co., May, 1890.

Family 4. THELEPHOREÆ Pers.

Craterellus Fr.

106. **Craterellus lutescens** Fr. Edge of thin woods, Yates.

Stereum Pers.

107. **Stereum fasciatum** (Schw.) Fr. Pk. 22 Rep., p. 81. On sticks in woods. It is doubtful if the species is really distinct from *Stereum versicolor* of which it is probably a mere form.

108. **Stereum striatum** Fr. Pk. 22 Rep., p. 86. This is the *Thelephora sericea* of Schweinitz. Common on fallen branches.

109. **Stereum albobadium** Schw. Pk. 24 Rep., p. 80. On wood in wood piles, Yates, Orleans Co.

110. **Stereum purpureum** Fr. Pk. 30 Rep., p. 75. On apple tree stumps, Lyndonville, April, 1888.

111. **Stereum complicatum** Fr. Pk. 22 Rep., p. 86. On old logs in woods, Ridgeway.

112. **Stereum radiatum** Peck. Pk. 26 Rep., p. 72. On Hemlock frames of cellar doors, Lyndonville, June, 1890.

HYMENOCHÆTE Lev.

113. **Hymenochæte tabacina** Lev. Pk. 22 Rep., p. 86. On dead limbs and branches, woods, Lyndonville. Our specimens appear to be the form described by Schweinitz as *Thelephora* (*Stereum*) *imbricatula*.

114. **Hymenochæte corrugata** Berk. On dead twigs, Yates, Orleans Co., May, 1890.

CORTICIUM Fr.

115. **Corticium incarnatum** Fr. Pk. 24 Rep., p. 80. Common everywhere on twigs and branches.

116. **Corticium salicinum** Fr. Pk. 24 Rep., p. 81. On twigs in woods, Yates, Orleans Co.

117. **Corticium livido-cœruleum** Karst. On limbs on ground in woods, April.

118. **Corticium alutarium** B. & C. On logs in woods, Ridgeway.

PENIOPHORA Cooke.

119. **Peniophora rhodella** (Peck) Sacc. Sacc. Syll. Fung., Vol. IX, page 239. Corticium Peck in 42 Rep., p. 28. The original specimens sent to Prof. Peck and upon which he founded the species were found on the inner surface of bark lying on ground in woods, Lyndonville, N. Y.

CYPHELLA Fr.

120. **Cyphella pezizoides** Zopf. On dead branches of basswood (Tilia.) Peck refers our specimens to *Cyphella Tiliæ*.

Family 5. CLAVARIEÆ Corda.

CLAVARIA Vaill.

121. **Clavaria aurea** Schæff. On ground in woods, late autumn, Yates, Orleans Co.

Family 6. TREMELLINEÆ Fr.

EXIDIA Fr.

122. **Exidia glandulosa** Fr. Pk. 22 Rep., p. 88. On small twigs on ground in wet places in the woods. Also occurs on *Rhus toxicodendron* branches, Yates and Ridgeway, Orleans Co., April, May.

123. **Exidia albida** (Huds.) Bref. On moist stumps, Ridgeway.

TREMELLA Dill.

124. **Tremella mesenterica** Retz. Pk. 22 Rep., p. 88. Common on moist hemlock stumps.

DACRYOMYCES Nees.

125. **Dacryomyces deliquescens** Dub. Common on wet fences in early spring or in a wet season.

126. **Dacryomyces fragiformis** Nees. On wood in piles in moist places, August, 1886, Lyndonville.

AUGUST 22, 1892.

SPECIAL MEETING.

HELD IN MUSIC HALL, Y. M. C. A. BUILDING, COMPLIMENTARY TO THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The President, PROFESSOR H. L. FAIRCHILD in the chair.

MR. GROVE KARL GILBERT of Washington, D. C., gave an address upon

COON BUTTE AND THE THEORIES OF ITS ORIGIN.

The lecture was illustrated with lantern views, and a relief map of the volcanic crater.

OCTOBER 10, 1892.

STATED BUSINESS MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

Forty-six persons present.

The Council report recommended the payment of certain bills, which by vote were ordered paid.

The resignation of the Secretary, DR. P. MAX FOSHAY was accepted, and a committee consisting of Reverend C. B. Gardner, Dr. J. E. Line, and Professor Charles W. Dodge, was appointed to draft resolutions of regret, who reported later as follows:

"As we have been called upon to receive the resignation of our worthy Secretary, Dr. P. Max Foshay, on account of his removal from the city, we cannot let acceptance of it pass without an expression of our sincere regret at the loss of so faithful and efficient a Secretary and so valuable a member of our Academy. Dr. Foshay having performed the principal part of the work of preparing our proceedings for publication, and furnished one of our most valuable scientific papers has merited our hearty thanks for his labor, and an expression of our appreciation of his success. We wish that he may be equally useful and acceptable elsewhere."

The report was unanimously adopted.

A letter from Professor F. C. Chamberlain of the Chicago University was read, soliciting contributions of the proceedings of the Society.

The following resolution was adopted :

Resolved:—That the hearty thanks of the society be extended to Mr. G. K. Gilbert for his lecture of Aug. 22, in Music Hall, under the auspices of the Society and complimentary to the American Association for the Advancement of Science.

Miss Beckwith announced that Mr. Gilbert Van Ingen, formerly of Cornell University, now of Yale University, had presented to the Academy a second collection of plants for the herbarium, consisting of 550 specimens, representing 335 species ; many being rare, and the collection as a whole being one of great value. 64 species embracing 117 specimens are new to our herbarium.

MR. F. D. PHINNEY, gave an interesting description of

BURMA, ITS LANGUAGE AND PEOPLE.

A vote of thanks was extended to Mr. Phinney.

OCTOBER 24, 1892.

STATED MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

Sixty persons present.

PROFESSOR H. F. BURTON read a paper on

BUILDING MATERIALS AND METHODS OF CONSTRUCTION EMPLOYED IN ANCIENT ROME.

The paper was illustrated with samples of the rock and other building materials.

NOVEMBER 14, 1892.

STATED BUSINESS MEETING.

The President, PROFESSOR H. L. FAIRCHILD, in the chair.

About fifty persons present.

The Council report recommended :

(1.) The election of MR. GILBERT VAN INGEN, as corresponding member.

(2.) The election of MISS HARRIET B. STARK, MR. A. W. LAWTON, DR. EVELINE P. BALLENTINE and MR. ELON HUNTINGTON, as active members.

(3.) The payment of certain bills.

The candidates for active membership were elected as recommended and the bills ordered paid. The election of the corresponding member went over under the rules.

In pursuance of a notice given at a previous meeting for the election of a Secretary, PROFESSOR ARTHUR LATHAM BAKER was elected Secretary.

REV. JOHN WALTON reported progress toward the completion of the collection of Mollusca presented to the Academy.

The President exhibited, with a descriptive commentary,

LANTERN VIEWS OF MEXICO.

December 12, 1892.

STATED BUSINESS MEETING.

The President, Professor H. L. Fairchild, in the chair.

A small number of members present.

The Council report recommended that the Secretary assume the clerical duties of the Treasurer, and receive an annual compensation of $200.

Action was deferred until next meeting.

The President introduced Mr. Heinrich Ries, of the New York State Geological Survey, who gave a short talk on

THE CLAYS OF NEW YORK STATE.

Miss Florence Beckwith read the following paper:

VARIATION OF RAY-FLOWERS IN RUDBECKIA HIRTA.

The first and principal variation to which attention is called is that of dark marks at the base of the ray-flowers. (See plate 11.)

In the summer of 1891, I found in a field, in the town of Gates, near Rochester, a few blossoms of *Rudbeckia hirta*, *L*, which differed from the normal type (fig. 1) in having a band of dark color at the base of the rays. This variation had never before been noticed by any of the members of the Botanical Section or by other local botanists to whom the flowers were shown. In 1892 the same field was again visited and more blossoms showing the same variation were found. This season a number of flowers with different markings were gathered, and these specimens seemed to form a well marked series. In some (fig. 2) there were only faint lines, like pencilings, at the base of the rays; in others (fig. 3) the lines were heavier and darker, the center line sometimes extending from the base to the apex of the ray; others showed small brown spots at the base; the rays of some of the heads (fig. 4) were all more or less shaded with brown; some (fig. 5) showed a band of orange; and at last the series culminated in specimens (fig. 8) in which the band at the base of the rays was as distinct and as dark in color as in *Coreopsis*. As the band grew more distinct in color the flowers decreased in size, those showing the darkest coloring being not much larger than the blossoms of *Coreopsis*. This observation corresponds to what may be seen in some other genera of the Compositæ.

Plate II.

Rudbeckia hirta L. showing variations in color.

1. Flower of normal yellow types.
2. Flowers with faint lines like pencilings at the base of the rays.
3. Rays with heavier lines at the base and one line extending from the base to the apex.
4. Rays shaded with brown.
5. Rays with a distinct and heavy orange band at the base.
6. A deepening of the normal yellow color at the base of the rays forming a dingy, yellowish brown band.
7. A light brown band at the base of the rays.
8. A full band of deep brown at the base of the rays.

Beckwith—Rudbeckia hirta.

The dark-banded flowers of both *Coreopsis* and *Gaillardia* are smaller than those of light color.

In a field about one-fourth of a mile distant from the first one visited, I found in 1892 a few blossoms showing faint pencilings on the rays, such as have been described, but none with a complete dark band.

Flowers showing an orange-colored band were reported in the fall of 1891, in "Meehans' Monthly," as having been noticed for the first time in the vicinity of Boston and Philadelphia.

If the plant has ever shown this variation before, it is strange that it has not been noted and reported, and it is equally strange if it has only recently taken this new departure. In a somewhat extended search in other directions around Rochester I have failed to find any other specimens than those of the normal type.

Another variation worthy of notice, is that flowers of the normal yellow color have been found with two or more circles of ray-florets, giving the appearance of so-called semi-double blossoms ; these were also found in the same fields.

Specimens showing the variations which have here been described, have been placed in the herbarium of the Academy.

PROFESSOR HENRY A. WARD showed a meteorite which he had recently received from Japan, from the village of Kesen, and read the following paper :

PRELIMINARY NOTICE OF A NEW METEORITE FROM JAPAN.

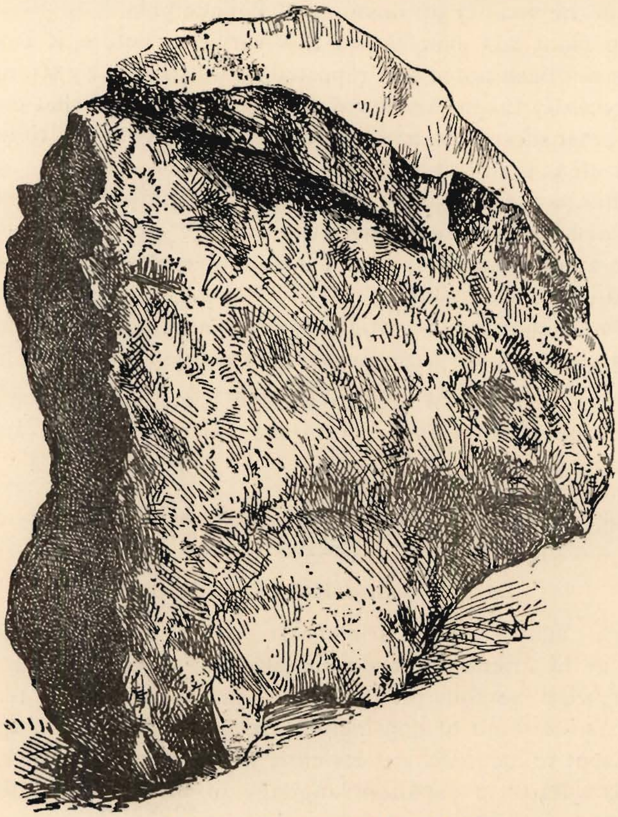
By PROFESSOR HENRY A. WARD.

Several months ago a friend, Mr. Alan Owston, who had been traveling in the interior of the main island of Japan, told me that he had seen what he thought to be a stone meteorite in a temple of Iwate. As the result of considerable correspondence this specimen has been sent to me, reaching me early in December. It was accompanied by a letter in Japanese language of which the following is a translation :

"This meteorite which I send you herewith fell about forty years ago, viz : in the 3d year of Ka-yei, at dawn on the 4th day of the 5th month, (13th June, 1850). It fell obliquely from the W.N.W. with a great sound like thunder, at the village of Kesen in the district of Kesen in this Prefecture. It entered the ground five feet, and remained hot for two days. The original size was said to be about equal to 2½ sho of rice. This would be about 1½ cubic feet. There were ten or more pieces of it which have been distributed about in various places.

(Signed) SATO KENJI, of Nota village, Iwate Prefecture."

The specimen which I have received is $6\frac{1}{16}$ ounces in weight. Its shape is an irregular triangle about 6½ inches in its greatest (vertical) diameter, and about 5 inches thick (see figure). Two long patches an inch wide on either side of the mass are covered with crust; the rest is



KESEN METEORITE, TWO-THIRDS NATURAL SIZE.

broken surface, showing inner structure. The crust has the usual characteristic pittings, very clearly indented, yet shallow. It is of a dull blackish brown color, with a pebbled or grained appearance. Close examination shows numerous shining metallic points, apparently of iron, with reddish stains, doubtless due to the oxidation of these. This surface shows clear signs of fusion, but there is no *flow* of the melted part, which might give clue to the direction of flight of the mass. The interior shows no signs of arrangement either in planes or concentric. There are several short fine fissures or fractures from one and a half to two inches in length, some of which reach to the lower side of the surface. They are not parallel, and they were doubtless caused by the shock of reaching the earth. One inner face however seems a little smoothed, as if prior to the breaking off of the contiguous piece there had been a sliding of surfaces. This stone is eminently chondritic. There is a fine-grained paste, and through it are distributed little rounded grains. Both the matrix and the grains are of the same material,—the minerals olivene and enstatite. This is all that is visible to the naked eye. But an ordinary low power lens shows many bright metallic points. Also glossy, waxy pimples of red color, perhaps an effusion of chloride of iron. Some larger blotches of iron rust occur here and there. In determining the metallic portion of the meteorite (whith has been done by Mr. John M. Davison of the Reynolds Laboratory of the University of Rochester), pieces of the mass were finely crushed and the metal separated by the magnet, washed in alcohol aud dried rapidly. Its weight having been taken, it was dissolved in nitric acid, and a little insoluble stony matter was separated, weighed and deducted from it. A mean of two determinations made in this way gave the metallic proportion about 16 per cent. of the whole mass. This is an unusual per cent. of metal,—much more than in the Waconda, which stone resembles in some respects the Kesen,—which we now name this new meteorite from Japan.

We are expecting to soon receive some other pieces, which may give new facts; and also a fuller examination of the mineral constituents—metallic and non-metallic,—will be made ere long.

Professor Ward formally christened the meteorite the "Kesen Meteorite," and gave a short description of the peculiar features of meteorites, particularly the plasmagraphs or mould marks, illustrated by the specimen before the Academy.

A general discussion followed, which was participated in by many of those present.

January 9, 1893.

FOURTEENTH ANNUAL MEETING.

The President, Professor H. L. Fairchild, in the chair.

Thirty-four persons present.

The Council report announced the appointment of the following Curators: Mr. J. B. Fuller, Curator in Botany; Mr. Shelley G. Crump, Curator in Conchology; Professor Albert L. Arey, Curator in Geology, and recommended:

(1.) The payment of certain bills, and

(2.) The election of Miss Carolyn D. Wood, as an active member.

The appointment of Curators was affirmed, the bills were ordered paid and the candidate elected by formal ballot.

The Annual Reports of the officers and sections were presented as follows:

Secretary's Report.

The report of the Secretary, Professor A. L. Baker, is summarized as follows:

During the past year eighteen meetings have been held.

Sixty-six active members, one honorary member and one life member have been elected. Sixteen members have been made fellows.

The total membership is:

Honorary members	10
Corresponding members	33
Active members	155
Fellows	40
Life members	1

Nineteen papers have been read, classified as follows: Geology, three; Meteorology, four; Botany, two; Ethnology, one; Mathematics, one; Zoölogy, one; Petrography, one; Archeology, one; Geography, two; Physiography, two; Paleontology, one.

Six lectures have been given, classified as follows:—Botany, two; Geography, one; Psychology, one; Geology, one; Paleontology, one.

REPORT OF CORRESPONDING SECRETARY.

The Report of the Corresponding Secretary was in his absence, read by the Secretary, as follows:

During the past year the work of the Corresponding Secretary has consisted mainly in distributing the Proceedings and receiving acknowledgments and exchanges in return. Of the last Brochure one hundred fifty-two (152) copies have been sent to active members, thirty-three (33) copies to corresponding members, and nine (9) to honorary members. In exchange for publications received from other scientific bodies, institutions of learning, libraries and investigators, one hundred forty-one (141) copies have been distributed in the United States and Canada, and two hundred ninety-six (296) have been sent to various places in Europe, Central and South America, Asia, Africa and Oceanica.

Applications for copies of the proceedings are frequently received from dealers in scientific publications and from libraries and societies not upon the exchange list.

Foreign exchanges are sent through the Smithsonian Institution with no other expense to the Academy than the railroad charges. The cost of distributing six hundred thirty-one (631) copies of the last Brochure will be about twenty-five dollars ($25.00).

Respectfully,

CHARLES WRIGHT DODGE,

Corresponding Secretary.

TREASURER'S REPORT.

The Treasurer, Mr. J. EUGENE WHITNEY, presented his report, of which the following is a summary:

Balance on hand, January, 1892	$144 52
Receipts during the year	651 00
Total	$795 52
Disbursements during the year	460 71
Balance on hand	$334 81

Number of members in arrears for dues, 23.

Librarian's Report.

The Librarian would respectfully offer the following report :

Number of bound volumes received during 1892,	10	
Number of pamphlets	572	
Total accessions for the year		582
Number of bound volumes in library	92	
Number of pamphlets	1511	
Total number of titles		1603

Mary E. Macauley,
Librarian.

Report of Botanical Section.

Read by Mrs. J. H. McGuire, Recorder of the Section.

The officers of the Society are : Miss Mary E. Macauley, President; Miss Florence Beckwith, Vice-President ; Mrs. J. H. McGuire, Recorder.

Extracts from the Minutes of the Section.

February 5, 1892. Over twenty-five specimens of Conifers were exhibited. Of these, a few were native, the remainder cultivated. Branches of ten species of Cornus were also examined.

February 26, 1892. The study of Conifers was continued.

Mrs. E. L. Maguire showed a number of pressed specimens of Western plants.

Dr. Searing showed pressed specimens of *Bryophyllum*, *Berberis a quifolium*, *Erigenia bulbosa*, *Mentzelia ornata*, and *Sarcodes sanguinea* the snow plant.

March 11, 1892. Mrs. King showed twigs of *Paulownia imperialis*, having buds, and last year's fruit.

Miss Beckwith exhibited seeds (mounted) of this tree, which were examined with the microscope.

Miss Macauley showed pods and seeds of Catalpa.

The subject of Conifers was resumed and the causes of the variations in the size of leaves of the same species, were discussed.

Miss Beckwith stated that Prof. Dudley had offered to the Academy, for the herbarium, such specimens of grasses, sedges and willows, as might be lacking to complete the list for this region.

Mr. Joseph B. Fuller proposed to present to the Academy his collection of unmounted specimens of plants, representing over nine hundred species, some of which are now extinct in this locality.

March 25, 1892. Microscopical studies.

Mr. Dumond exhibited *Bacillus subtillus* of twenty-four hours' growth. The bacteria were obtained from a boiled infusion of hay, planted on the inner surface of a cooked potato. Mr. Dumond stated that he had found them highly motile, but when exhibited to the class no motion was seen. Mr. Dumond also showed specimens of Oscillaria. In addition to the common forms, were some in the form of a spiral coil, narrowing from the base to the top, like a cone.

April 8, 1892. The subject of study was the red and the white Maples.

Mr. Fuller stated that he had found *Acer rubrum* with yellowish petals.

Mr. Fuller showed a specimen of *Ulmus racemosa*. Blossoms of *Sanguinaria Canadensis*, and *Hepatica* were shown.

April 22, 1892. Among the numerous Spring blossoms shown, were typical specimens of *Hepatica triloba* and *H. acutiloba*, showing the difference in the species in a marked degree.

Mr. Laney exhibited a number of willows, a large and interesting collection of branches of California shrubs, and a large cone of *Pinus ponderosa.*

Miss Beckwith exhibited a collection of plants from Tennessee among which were *Rhododendron nudiflorum, and R. viscosum*, *Houstonia cœrulia*, *Anemonella thalictroides*, *Cornus Florida*, *Æsculus glabra*, and *Æ. flava*, *Cercis Canadensis*, *Hepatica triloba*, and berries of Smilax *bona-nox*. These were especially interesting as showing the earlier blossoming in that latitude.

May 6, 1892. Mr. Fuller reported finding *Ranunculus fascicularis* April 27.

Mr. Laney reported that Mr. H. B. Brown had found one specimen of *Daphne Mezereum* in Seneca Park. Also, that *Amelanchier Canadensis* was now in blossom.

May 20, 1892. Mr. Fuller exhibited specimens of *Lamium maculatum*, (cultivated) and *L. amplexicaule*, (native) comparing and noting the existing differences. Among the very large number of plants examined were, *Chrysosplenium Americanum*, and *Lycopodium lucidulum.*

June 3, 1892. Mr. Fuller exhibited specimens of leaves of Maple, showing the differences between the red and the white varieties.

Mrs. King showed *Erigeron Philadelphicus*, *Lathyrus ochroleucus*, and a leaf of *Hepatica*, having an extra lobe.

Miss Beckwith showed a pressed specimen of a double *Trillium*, found in Agate, Lewis Co., Washington.

A number of leaves of different species of oaks were examined.

A number of flowers were also examined, among which were, *Habenaria bracteata*, *Castilleia coccinea*, *Viola striata*, *Polygala paucifolia* and *Staphylea trifolia*.

In microscopical studies, Mr. Streeter exhibited some very fine specimens of *Euglena*, and a species of *Oscillaria*, having a brown color, and not heretofore exhibited in the Section.

June 17, 1892. An excursion to Bergen on the eleventh inst., was made by the members of the Section.

They reported having found forty-eight species. Among those most worthy of notice were : *Listera cordata*, *Arethusa bulbosa*, *Habenaria Hookeri*, *Cypripedium spectabile*, *C. candidum*, *C. parviflorum* *C. pubescens*, *Linnœa borealis*, *Pyrola chlorantha*, *Vaccinium stamineum*, *Ledum latifolium*, *Quercus bicolor*, *Gaylussaccia resinosa*, *Asclepias quadrifolia*, *Triglochin maritima*, *Sarracenia purpurea*, *Acer spicatum*, *Smilacina bifolia*, *S. trifolia*, *S. stellata*, *Trientalis Americana*, *Myrica Gale*, *Polygala paucifolia*, *Medeola Virginiana*, *Valeriana sylvatica*, *Mitella nuda*, *M. diphylla*, *Coptis trifolia* in fruit, *Lonicera oblongifolia*, *Aphylion uniflorum*, and the unnamed variety of *Salix lucida* referred to by Professor Dudley in the "Cayuga Flora."

Among other plants exhibited were, *Eriophorum polystachyon*, *Oryzopsis Canadensis*, *Potentilla fruticosa*, and *Senecio aureus*, *var. Balsamitæ*. A collection of dried grasses from Dutchess County was also shown.

July 1, 1892. Mr. Laney showed a large variety of cultivated flowering shrubs.

Mr. Fuller showed specimens of *Pentstemon lævigatus* found at Pittsford.

Miss Macauley exhibited a rose found growing in this city, with stem extended through the flower bearing a bud on the summit.

Miss Beckwith exhibited a spike of *Digitalis lanata*, found near Canandaigua.

Mrs. Kempe showed *Leucanthemum vulgare*, having tubular ray-flowers, found in Greece. These daisies were found by Mrs. Kempe in the same locality in 1889, and are similar to specimens sent to the

Academy from Poughkeepsie by Mr. Gilbert Van Ingen. In the appendix of Gray's 5th edition, such abnormal growths are mentioned.

Dr. Searing exhibited a number of pressed specimens of Cypress, and other California plants collected by her on her recent trip to that State.

July 29, 1892. Miss Beckwith exhibited an interesting series of *Rudbeckia hirta*; beginning with the usual type, the series showed a tendency to variation in color at the base of the rays, the first having slight marks at the base, others a deeper hue, until a complete ring was shown, which in the last one was as conspicuous as the dark band of *Coreopsis*. A letter from Mr. Thomas Meehan, of Philadelphia, to whom Miss Beckwith had sent specimens was read.

Miss Beckwith exhibited specimens of *Rhododendron maximum* from the vicinity of Buffalo, and *Moneses uniflora*, collected in Irondequoit, near the Sea Breeze, by Warner W. Gilbert, and not before brought to the Section.

Miss Macauley reported that she had found *Moneses* for the first time, also near the Sea Breeze.

Miss Beckwith also showed the ordinary *blue Brunella*, and two specimens of unusual colors, one pink, the other white.

August 12, 1892. Miss Beckwith reported the arrival of a collection of plants for the Academy from Mr. Gilbert Van Ingen. This collection comprises 550 specimens of 335 species.

September 23, 1892. Among a large number of plants examined were *Gentiana crinita*, *G. Andrewsii*, and *G. quinqueflora*.

October 7, 1892. Mr. Fuller showed a specimen of *Campanula rotundifolia*, having the cluster of round leaves at base, and which also showed the gradual change to *lanceolate*; also, *Cratægus tomentosa*, *C. Crus-galli* and *C. punctata*, red and yellow fruited.

Dr. Searing showed a cone of Sugar Pine from Yosemite Valley, Cal. This cone was over a foot long.

October 21, 1892. Mr. Dunbar showed plants of *Sarracenia purpurea*; also, *Andromeda polifolia*, *potentilla fruticosa*, *Lycopodium clavatum*, *Cassandra cucullata*, *Abies nigra* and others from Mendon Ponds. Mr. Dunbar also showed a number of specimens of Evergreens from the estate of Charles A. Dana on Long Island, who is said to have the finest collection of these trees in this country.

December 2, 1892. Mr. Dunbar exhibited *Cnicus laciniata* and several species of cultivated Japanese plants.

December 16, 1892. Professor Lennon exhibited pressed specimens of *Trifolium procumbens*, just introduced this year in Brockport; also, *Potentilla recta*, and a new unnamed Vetch.

Mr. Dunbar showed pressed specimens of *Calamintha glabella*, gathered at Niagara Falls, and berries of *Smilax rotundifolia*, and various shrubs from foreign countries.

Mr. Laney reported a new station for *Rhododendron maximum*, it having been discovered in Penfield, by Mr. James H. Brown. This is justly regarded as a very important discovery, for the station is decidedly north of its usual habitat. A few stations are known near Buffalo, and only about twelve in the entire state.

December 30, 1892. Mr. Fuller showed pressed specimens of leaves of *Rhus juglandifolia* and *Juglans nigra*, noting differences.

Report of Curator in Botany.

During the year 1892 there were added to the herbarium of the Academy a small collection of Ferns from the Island of St. Helena, the gift of Lieutenant Commander Franklin Hanford, U. S. N.; a collection of about 2,500 specimens from Mr. Joseph B. Fuller; and two collections, numbering in all over 500 specimens from Mr. Gilbert Van Ingen of Poughkeepsie. Through the kindness of Dr. Daniel G. Hastings of this city, we have also been recently favored by the gift of a part of the herbarium of the late Dr. Samuel G. Bradley, of West Greece, who was one of the early botanists of this section of country, and who is often quoted as an authority on the flora of this vicinity. This herbarium, though dating back in part to 1843 is in a very good state of preservation, and will not only be very valuable to us for comparison, but will also enable us to add some to the list of our native flora. There are about 250 specimens in this collection.

There are now in the herbarium, including Dr. Bradley's collection, about 5,000 specimens, over 2,100 of which are regularly mounted and labeled.

The collections given us have added many species new to the herbarium.

FLORENCE BECKWITH,
Curator in Botany.

MR. GILBERT VAN INGEN of Yale University, was elected a corresponding member.

It was voted that the Secretary be paid a salary of $200.

ELECTION OF OFFICERS.

The following officers were elected for the ensuing year:

President, HERMAN L. FAIRCHILD.
First Vice-President, J. M. DAVISON.
Second Vice-President, M. L. MALLORY.
Secretary, ARTHUR LATHAM BAKER.
Corresponding Secretary, CHARLES W. DODGE.
Treasurer, J. EUGENE WHITNEY.
Librarian, MISS MARY E. MACAULEY.
Councillors, H. L. PRESTON. F. W. WARNER.

In the absence of the author the following paper was read by the President:

ESKERS NEAR ROCHESTER, N. Y.

A DISCUSSION OF THE STRUCTURE AND ORIGIN OF THE PINNACLE HILLS.*

BY WARREN UPHAM.

CONTENTS.

THE AREA SPECIALLY STUDIED.

On the southeastern border of Rochester, N. Y., a remarkable esker series, named the Pinnacle hills, extends nearly four miles from east-northeast to west-southwest, rising from an approximately level country and forming the only conspicuous elevations of land close to that city. Under the guidance of Mr. G. K. Gilbert, this esker was examined by most of the geologists who attended the meetings of the Geological Society of America and of Section E of the American Association for the Advancement of Science in Rochester last August, and on the following morning about an hour was

*This paper was originally prepared for and read at the Ottawa meeting of the Geological Society of America, December 29, 1892.

given to discussion of the manner of its formation through the agency of the ice-sheet and the streams produced by its melting. Before stating some of the opinions brought out in that discussion, and attempting a full inquiry concerning the processes of accumulation of this and other eskers and kames, we will first go again, as I did on following days, over the Pinnacle hills and describe their contour and numerous sections exposed by excavations for road material and for the passage of streets. The other drift deposits and contour of their vicinity will be noted, and a second series of eskers lying several miles farther southeast in Pittsford, which I also examined, will be described, with their relationship to prominent drumlins near, and to terminal moraines more remote, on the south.

Description of the Pinnacle Hills.

From Brighton village and station on the New York Central railroad, three miles southeast from the station in Rochester, this prominent range of hills extends in an almost straight course about four and a half miles west-southwesterly to the Genesee river close south of the State dam. In passing the east end of this esker, the Erie canal turns from a due east to a due south course. Along its first mile from Brighton the esker rises 75 to 150 feet above the country on each side, and declines in height from 125 to 75 feet near the western end of this portion, where it is known as Cobb's hill. Immediately to the west, near the residence of Mrs. W. H. Cobb, a sag in the esker, as it was originally, before being cut down for the extension of Monroe avenue, had a height of only about 50 feet. Next westward the esker rises in the distance of a half mile to its highest point, called the Pinnacle, 200 feet above the nearly plain region on the north and south. Thence the continuation of the esker along its next two miles, varying in altitude mainly from 150 to 100 feet above the general level, is occupied, in order from east to west, by the St. Patrick Cemetery, the Highland Park, which includes the Mt. Hope reservoir in its western part, and the extensive Mt. Hope Cemetery. In its next mile west to the river, the ridge is lower, having a height of only 80 to 50 feet above the State dam. The northeastern end of this hill range at Brighton is very definite, overlooking a wide expanse of the low land ; but its western end is indefinite, for in the line of its continuation west of the Genesee it is represented along a distance of at least two miles (which is as far as my examination extended) by a low ridge, mostly 30 to 40 feet above the general level. Between the Mount Hope Cemetery and the Genesee river and farther to the west, the material of the ridge is largely till, which shows that low portion to be a marginal or interlobate moraine ; but the high range of the Pinnacle hills from Brighton to the Mt. Hope Cemetery is clearly an esker, 3½ miles long, consisting of interbedded gravel and sand, here and there enclosing boulders, sometimes in surprising abundance, but containing no till in the extensive sections nor on its surface.

The width of this hill range is mostly about a sixth of a mile, but varies from a tenth to a half of a mile. Along its whole extent it is a single range, nowhere presenting a combination of parallel series of hills ; but, in some parts, especially in the Highland Park and near the reservoir, it is incised on each side by ravines between spurs and outlying hillocks of the main belt, and its top is occasionally very uneven in contour, with infrequent bowl-shaped hollows 10 to 50 feet below the surrounding surface. The profile of its crest line undulates in an irregular way, generally varying 50 to 100 feet in height upon each mile or half mile ; and it nowhere maintains a level course for any considerable distance. In the vicinity of the Pinnacle and in many other places, the slopes on each side are very steep, ranging to a maximum of about 30 degrees ; and the crest line has occasional slopes of half this steepness. More commonly, however, the slopes vary from 6 to 15 degrees, having from 10 to 25 feet of ascent in a distance of 100 feet.

When my first contribution to geology was published, sixteen years ago, "On the origin of Kames or Eskers in New Hampshire," ([1]) these classes of the modified drift, produced jointly by the ice-sheet and the water of its melting, had not been discriminated from each other. Every knoll, hillock or hill, short or long ridge, or series or network of ridges composed of irregularly and often anticlinally bedded gravel and sand, retaining nearly the original form in which it was accumulated, was then called interchangeably a *kame*, *esker*, or *as*, or a series of *kames*, *eskers*, or *asar*. The first of these terms is of Scottish, the second of Irish, and the third of Scandinavian origin, the last being Anglicized to *osar*, with *osars* as its plural form. It is found very desirable, however, to subdivide these gravel and sand accumulations into two classes, as proposed by McGee ([2]) and Chamberlin, ([3]) giving to the hillocks and short ridges the name

(1.) Proc. A. A. A. S., Vol. XXV, for 1876, pp. 216–225.
(2.) Report of the International Geological Congress, second session, Boulogne, 1881, p. 621.
(3.) U. S. Geological Survey, Third Annual Report for 1881–82, p. 299; Am. Jour. Sci., III, Vol. XXVII, 1884, p. 389.

kames, while the prolonged ridges are termed *eskers* or *osars*, excepting their peculiar development in northeastern Iowa, where they are composed chiefly of loess or fine silt and have received the name *paha*, alike whether singuiar or plural. ([1]) Kames, as thus defined, usually or often constitute an important part of the terminal moraines, and they are also frequent on many other portions of our drift sheet. Eskers are found likewise both in the vicinity of terminal moraines, sometimes being evidently of closely contemporaneous origin, and also remote from moraine belts. In length the eskers or osars vary from a mile or less to several miles, and in Maine and Sweden they extend in many continuous series, 20, 50, and even 100 miles or more. Their courses are commonly somewhat crooked, like those of rivers, but in general they run in parallelism with the glacial striæ and directions in which the ice-sheet moved and carried its boulders and other drift.

The structure of the Pinnacle hills esker is well exhibited near its northeast end, near Monroe avenue, and at various places separated only by short intervals, thence westward to Mt. Hope avenue and cemetery, by excavations for the use of its gravel and sand in road-making and masonry. Less than a quarter of a mile south of Brighton, a cut on the northern slope of the east end of the esker, just east of the north to south road (Arbutus avenue), has a depth of about 30 feet and length of some 12 rods. The upper 10 feet are fine gravel and sand, almost levelly bedded, beneath which the remainder of the section consists of very coarse but distinctly stratified gravel, with a nearly uniform dip of 15° W. S. W. This coarse gravel contains cobbles and rock fragments of all sizes, up to 1½ feet in length, packed closely together, their interstices being filled with finer gravel, sand, and very fine silt. About two thirds of all the stones are much water-worn, so as to have rounded forms ; nearly all of the remaining third are somewhat worn, being subangular ; and only about a twentieth part are rather sharply angular, with little or no evidence of attrition in their transportation by the glacial river. Fully half of the small gravel, up to six inches in diameter, are Medina sandstone ; and about a third of the cobbles and masses from 6 to 18 inches in diameter are Archæan gneissoid rocks. Only four boulders of larger size, none of these exceeding four feet in diameter, were seen in this section.

Close west of this road, nearly opposite to the foregoing and at a distance of 10 to 30 rods southwest from it, a larger excavation,

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(1.) W J McGee, "The Pleistocene History of northeastern Iowa," in the Eleventh Annua Report of the U. S. Geol. Survey, for 1889–90.

also in the northern side of the esker, consists almost wholly of fine gravel and sand, with stratification mostly inclined 5° to 20° southward. This section, 30 to 40 feet deep, and the surface of the esker immediately adjoining it, have only very rare boulders; but within a short distance the southern slope of the ridge, where it is cut for the road, has many boulders on the surface and in the upper 10 feet of the gravel and sand. The rather broadly rounded top of the esker is here about 80 feet above the general level on the north, east and south. In its central part, 25 feet below the top and some 20 rods from its northern base, a small space of this section, 10 feet long and 6 feet in height, shows three sharp faults, each having 2 to 3 feet of displacement, with overthrust from south to north. The beds overlying the faulted portion, which was near the bottom of the excavation, and the continuations of the faulted layers away from this place on each side, were undisturbed, dipping 10° to 15° S. or S. S. W. Fifteen to 40 feet east from these faults, slightly higher beds show eight repetitions, within a thickness of 8 feet, of layers of gray gravel, 3 to 12 inches thick, separated by layers of fine yellow sand 1 to 3 inches thick. These alternations probably represent the rapid and strong currents of a glacial river during the fast melting of the ice surface by day and the slow currents at night, when ablation was at its minimum or ceased.

Another large excavation 300 to 500 feet west of the last, likewise in the northern side of the esker, has a vertical face of 40 to 50 feet, consisting of interbedded gravel and sand in its upper half, while its lower half is mostly sand. The largest cobbles in the gravel are about one foot in diameter, and no boulders were observed. Mainly the dip is 10° to 20° southward, but at the east end of this section its upper 10 to 15 feet are much contorted, with a prevailing northerly dip of 10° to 15°.

In the southeastern side of the esker, opposite to Mrs. W. H. Cobb's house, an excavation about 25 rods long and 50 to 60 feet high consists in its upper part, to a depth of 6 to 20 feet from the surface along its whole extent, of sand and very coarse gravel enclosing exceedingly abundant boulders of all sizes up to 6 or 8 feet in diameter, far more plentiful than in the ordinary till of this region. Below this portion, the remainder of the section, extending downward 30 to 40 feet, is irregularly interstratified gravel and sand, with only infrequent boulders. The whole section shows stratification by currents of water, and according to my estimate nineteen twentieths of the gravel and small rock fragments are rounded or at least much worn on their edges and corners.

Other sections which were examined in our excursion on the northern slope of the esker near this place and about a quarter of a mile to the northeast, show the same astonishing profusion of boulders with the upper coarse gravel, underlain by beds having fewer boulders. The gravel and sand are characterized by irregular and often oblique bedding, variable thickness of individual layers, and occasional oblique or nearly vertical faults with small amount of displacement ([1]). Boulders are also strown in considerable numbers on the surface of this part of the esker, but elsewhere along most of its extent they are usually rare both on the surface and in excavations. Mr. Gilbert called attention to the origin of the boulders, and pointed out the very significant fact that many of them are of the Niagara limestone, which can have been transported no more than three or four miles from its parent ledges, since the northern limit of this formation lies within that distance. Some of these boulders were seen on or near the Pinnacle, at least 200 feet above the outcrops on the plain country northeastward from which they must have been derived.

Continuing over the Pinnacle and through the Highland Park, I examined numerous sections, all of which were interbedded gravel and sand with only very rare boulders or more commonly none. Occasionally, however, a boulder 5 or even 10 feet in diameter is found on the surface, or in a section, remarkably in contrast with the water-deposited sand and gravel, in which the largest pebbles and cobbles range from a few inches to a foot, or seldom one and a half feet in diameter. From the Pinnacle to the Mount Hope cemetery, most of the excavations are chiefly sand.

The cut made west of this cemetery by a branch of the New York, Lake Erie & Western railroad has a length of nearly a quarter of a mile from north to south and is from 15 to 25 feet deep. Large portions of this section are true till, or clay, sand, and small and large rock fragments, mingled in an unstratified deposit ; but, like the till of the surrounding country, it contains only few large boulders. Among the half dozen boulders of greater size than two feet in length seen in the eastern face of this excavation, one of the largest, about five feet in diameter, was Niagara limestone. With the depos-

(1.) Numbers 323, 324 and 325 of the list of photographs of the Geological Society of America (Bulletin, G. S. A., Vol. III, p. 472) are views of sections of the Pinnacle hills esker at this locality, photographed and presented by Professor H. L. Fairchild.

its of till are many intercalated layers of stratified sand, from 1 to 5 feet in thickness, often continuous along a distance of 100 feet or more. These layers are mostly horizontal or only slightly inclined, and no contortion nor evidence of erosion or tumultuous pushing forward was observed.

Beyond its intersection by the Genesee river, this ridge is the site of the Rapids Cemetery, and thence it extends nearly due west two miles along or close to Brooks avenue. It rises by usually gentle slopes 30 to 40 feet above the land on its south and north sides, and has a width of 25 to 50 rods, being often quite irregular in contour, which with its clayey soil and occasional boulders, gives it a morainic aspect. Where it is cut by the Buffalo, Rochester & Pittsburgh railroad, nearly two miles west of the river and between an eighth and a third of a mile north of Brooks avenue, several recent excavations showed about half of its material to be till, and the remainder very compact stratified sand. These unlike deposits are irregularly accumulated together, but no interblending was seen. The till has no marks of water action, and the sand is free from boulders or gravel, and is horizontally bedded or nearly so, being sometimes 5 to 15 feet thick with an exposed extent of fully 100 feet.

Relationship to the surrounding Country.—Throughout the city of Rochester, excepting the Pinnacle hills and the gorge of the Genesee below its falls, the surface is nearly a plain, with slight descent toward Lake Ontario. The underlying Niagara and Clinton formations are covered generally with only 10 to 20 feet of drift, which is mainly till and in small tracts stratified clay or sand and fine gravel. Northward from Rochester, the surface in Irondequoit and Greece townhips declines with a gradual slope 200 to 250 feet in the distance of 5 to 7 miles to Lake Ontario.

The fjord-like Irondequoit bay, lying between Irondequoit township on the west and Webster and Penfield on the east, stretches about five miles southward from Lake Ontario, with a width varying from one mile to a half mile, bordered by cliffs 100 to 200 feet high, which rise to the general plain on each side. The maximum depth of Irondequoit bay is 80 feet, which must be added to the height of the bluffs to give the total depth of the eroded valley; and its southern end, where the Irondequoit river flows into it, is about five miles east from the center of Rochester. Before the Ice age the Genesee doubtless entered the lake through this valley, probably leaving its present course near the mouth of the Honeoye creek, flowing eastward, through Bush township and the southern part of Mendon, and thence northward along the Irondequoit river and bay. In the southeast edge of Pittsford the Irondequoit, where it is crossed by the Erie canal and for three miles southward, is about 100 feet lower than the Genesee near the south line of the city of Rochester, above the State dam. Especially thick accumulations of the glacial drift in Mendon caused the Genesee after the Ice age to take its new course through Rochester; and its rock gorge, extending from the center of this city to its mouth at Charlotte, has been eroded during the Postglacial or Recent epoch, of which, like the gorges below the falls of Niagara and of St. Anthony, it affords a means of measurement, if the extent of recession of the Genesee falls during the present century can be determined.

Southward and eastward, elevations of equal height with the Pinnacle hills are first found at the distance of 7 to 10 miles, being prominent drift accumulations later to be described in this paper, lying in the southwest part of Pittsford and northwestern Mendon, and between Victor and Fairport.

The relation of the Pinnacle hills to the adjoining region will be further exhibited by the following list of altitudes, which are mostly derived from maps in the office of Mr. J. Y. McClintock, city engineer of Rochester, others being from the United States Lake Survey. They all are referred to mean tide sea level.

Altitudes in Rochester and its Vicinity.

	Feet above the sea.
Lake Ontario, low and high water, 245–249; ordinary stage	247
Iroquois beach, between Irondequoit bay and the Genesee river (Gilbert)	436
Erie canal, coping and tow-path of viaduct crossing the Genesee river in Rochester, 510; water	508
New York Central railroad track at Rochester station	516
Wide Waters of the Erie canal on southeastern line of Rochester	500
Railroad at Brighton station	460
Canal at Brighton	480
Summit of Arbutus avenue one-fourth mile south of Brighton, crossing the east end of the Pinnacle hills esker	536
Top of esker about 50 rods west of last	570
Top of esker one-third mile farther west	652
Depression close southwest of last	590
Highest point of Cobb's hill, one-third mile farther W. S. W.	663
Top of esker about 40 rods westward	608

	Feet above the sea.
Intersection of Monroe and Highland avenues, at Mrs. W. H. Cobb's residence, immediately south of last	544
The Pinnacle, one-half mile farther west	749
Summit of Pinnacle avenue, crossing the esker one-third mile farther west	583
Top of esker in Highland park, at the Memorial Pavilion	650
Mt. Hope reservoir, water surface	634
Summit of South avenue	617
Summit of Mt. Hope avenue	622
Highest portions of the esker in Mt. Hope cemetery, about	675
Crest of morainic ridge extending westward as a continuation of the Pinnacle hills, where it is cut by the Genesee Valley branch of the New York, Lake Erie & Western railroad	583
Same, on east bank of the Genesee river	559
Same, west of the river, at the Rapids cemetery and onward	555–560
Genesee river above the State dam, near the foregoing	508
At foot of this dam	504
At the Clarissa street bridge	502
At the Court street bridge	493
At the Andrews street bridge	484
Upper falls, top of rock, 476 ; water in ordinary stage at brink and foot of the fall	473–387
Above and below the Middle falls	374–348
At mouth of Deep Hollow creek and brink of Lower falls	345
At foot of Lower falls	251
At the steamboat landing, about one mile north of the last, on the level of lake Ontario	247
Seneca Park bridge, spanning the gorge close below the Lower falls	460
Highest ground at the Rochester University	520
Canal and railroad at Pittsford, about	460
Irondequoit river under the viaduct of the Erie canal, about	400
Turk's hill, a station of the U. S. Lake Survey triangulation, near the south line of Perinton township, about 12 miles southeast from the Pinnacle hills	928
Rush reservoir of the Rochester Water Works, 9 miles south of the Mt. Hope reservoir	753
Hemlock lake (maximum depth, 87 feet), source of the Rochester water supply, 19 miles from the Rush reservoir	898

Eskers in Pittsford.

From 2½ to 3 miles southeast of Brighton, the New York Central railroad makes a long cut through the northern end of a second esker series, which takes a course approximately at right angles with that of the Pinnacle hills. Beginning close south of Allen's creek, in the southwest corner of Penfield township, this belt of kames and eskers runs south-southeasterly through the east half of Pittsford and about a mile into the southwestern corner of Perinton, terminating in a sand plateau, which abuts upon the western base of the prominent Turk's hill range of drumloid drift. The length of this Pittsford esker series is about seven miles.

In its northern third, extending from Allen's creek southward to about a mile east of Pittsford village, the width of this belt varies mainly from a half mile to fully one mile, and it consists of a principal broad north to south esker ridge, becoming narrower and interrupted southward, with a considerable lateral expansion, especially on the east, in kames, or short ridges, mounds and hillocks, all being composed of sand and gravel, with infrequent enclosed boulders. The cut for the railroad is about a half mile long and 50 feet deep. Its greater part is yellow sand, nearly horizontal in stratification, excepting at the margins, where the bedding is more irregular, prevailingly dipping downward like the surface slopes. In this sand are occasional thin gravelly layers, but these are nowhere conspicuous. Very rare embedded boulders were seen. Only two, which were respectively about 3 and 5 feet in diameter, were exposed in the section at the time of my visit, and scarcely a half dozen in total lie at the foot of the banks on both sides of the railroad. The basal part of this section, however, for about an eighth of a mile west from its center, consists of coarse gray gravel, containing very closely packed gravel stones and cobbles up to 6 or 8 inches in diameter, but no larger boulders. On the north side of the excavation the gravel reaches to a height of about 20 feet above the track, and displays a very distinct anticlinal stratification.

About 1½ miles southeast from this railroad cut, a small excavation for the passage of a north to south road through a kame deposit, chiefly of sand, near the east line of Pittsford and the east border of the esker and kame belt, reveals a boulder 3½ feet in diameter, embedded 10 feet below the surface. Beneath and above the boulder, the stratification of the sand and gravel is contorted and curved, in conformability with the outline of the rock mass.

After an interruption or gap about 40 rods in length, the more southern portion of the series, from a point about a mile east-southeast of Pittsford village to its termination about a mile southeast and south of the village of Bushnell's Basin in Perinton, is well described as follows, by Mr. Charles R. Dryer, in a paper which also treats of the Pinnacle hills, Irondequoit bay, and the massive hill ranges of till south of Pittsford and Fairport (1). Mr. Dryer, following the early usage of the term *kame*, applies it to the narrow esker ridge, with steep slopes and sharp crest, which he describes one to three miles southeast of Pittsford, succeeded in the next mile or more by a sand plain or plateau.

"The north end is a sharp ridge of very coarse gravel, fifty feet in height, one mile long, and in shape like a rude fish-hook. It is separated from the southern portion by the channel of Irondequoit river, which has cut the kame completely in two. In the southern portion the gravel is overlaid by fifty feet of fine sand which spreads out toward the southeast in a sheet a mile or more in width. This kame forms a dam across the valley, complete except for an interval of less than one-fourth of a mile on its western side. The Erie canal avails itself of this kame to cross the valley and by a fifty-foot embankment restores what probably once existed as a natural feature. South of the kame the valley is as level as a floor for three miles up the stream and was evidently once the site of a lake whose waters were held back by the kame as a dam."

Relationship to Drumlins and Terminal Moraines on the south.—To understand the history of the recession of the ice-sheet in this region and of the accumulation of its drift, it is needful for us to take for a moment a somewhat broad view southward. Beginning within a half mile south of Pittsford, drumlins are admirably developed upon an area extending six or seven miles to the south, into the northwest part of Mendon. They also form the crests of a massive drift ridge which stretches from Fairport south to Victor, culminating in Turk's hill; and beyond a depression, through which the railroad from Rochester to Canandaigua passes, similar massive, drumlin-crowned highlands extend from Victor several miles to the south and southwest. These highlands appear to me referable to the class of drumlins, rather than to that of terminal moraines marking the outlines of the ice-front at any stage of temporary halt in its general retreat. Eastward from this region, drumlins occur in extraordinary abundance for a distance of 60 miles, to the vicinity of Syracuse (2).

(1.) The Glacial Geology of the Irondequoit Region, Am. Geologist, Vol. V, pp. 202-207, with map, April, 1890.

(2.) L. Johnson, "The Parallel Hills of Western New York," Trans., N. Y. Acad. of Sci., Vol. I, 1882, pp. 78-80; Annals, do., Vol. II, pp. 249-266, with map.

D. F. Lincoln, "Glaciation in the Finger Lake Region of New York," Am. Jour., Sci., III, Vol, XLIV, pp. 290-301, Oct., 1892.

Warren Upham, "Conditions of Accumulation of Drumlins," Am. Geologist, Vol. X, pp. 339-362, Dec., 1892.

Between 35 and 60 miles south of Rochester, conspicuous terminal moraines run approximately from west to east, as described and mapped by Professor T. C. Chamberlin (1). On the meridian of Rochester these moraines are somewhat interblended, fragmentary, and irregular in their development upon a width of nearly 25 miles from the southern ends of Conesus and Hemlock lakes southward to the vicinity of Hornellsville. Farther to the east, for a distance of about 150 miles, to the Catskill mountains and the Mohawk river, they are more distinctly developed as two morainic belts, of which the southern one is traced in a slowly curving course, convex toward the south, along the valleys of the Canisteo, Tioga and upper Susquehanna rivers, while the northern one passes in a more sharply curved and lobate course by the south ends of the Finger lakes to Ilion and Herkimer on the Mohawk. In the valleys extending southward from the heads of the larger Finger lakes the thickness of the northern moraine appears to be several hundreds of feet, and in the case of Seneca lake perhaps more than 1,000 feet; but on the intervening plateaus the thickness of the morainic drift is comparatively insignificant, averaging probably no more than 25 to 50 feet upon widths varying from one to two or three miles.

A more distant moraine, however, lying on and near the boundary of the glacial drift, extends from the vicinity of Salamanca, N. Y., east-southeasterly to the Delaware river at Belvidere, N. J., and to Staten Island, the Narrows, and Long Island. This moraine, described in Pennsylvania by Professors Lewis and Wright, (2) passes about 100 miles south of Rochester.

Relationship to Glacial Movements.—The currents of the ice-sheet flowed perpendicularly toward its boundaries and marginal moraines, that is, to the south or somewhat west of south for the region about Rochester and Pittsford; but during the recession of the ice from that area, its currents were in some portions deflected much to the west, because of more rapid melting of the ice on that side and consequent indentations or embayments in its border. This faster melting on the west was probably at first due in large part to the laving action of the glacial Lake Warren, which extended from the western part of the basin of Lake Ontario over the upper Laurentian lakes, outflowing at Chicago to the Des Plaines, Illinois, and Mississippi rivers; and in the later stage of the glacial recession when the Roch-

(1.) Third Annual Report of the U. S. Geol. Survey, for 1881–82, pp. 351–360, with Plate XXXIII.

(2.) Report Z, Second Geol. Survey of Pennsylvania.

ester and Pittsford eskers were formed, the ice-melting was likewise promoted by the incipient Lake Iroquois, outflowing by Rome to the Mohawk and Hudson.

According to notations of glacial striæ by Chamberlin, Gilbert, and Dryer, their courses are as follows : near the northeast corner of the city of Rochester, S. S. W. to S. W.; near the southwestern boundary of this city, S. W. to W. S. W.; and in Greece, the next township northwest of Rochester, four courses, intersecting or on contiguous rock exposures, S. S. E., S. S. W., S. W., and W. The southward courses are doubtless somewhat earlier than those running to the southwest and west, which belong to the short time when the glacial currents were deflected during the departure of the ice. Upon all the region of the Finger lakes the glacial striation is approximately from north to south, in parallelism with these lakes and the intervening ridges and plateaus. On the north the grand ice currents over the Province of Ontario moved mainly southward, with convergence from the southern part of Georgian Bay southeasterly, and from Montreal and the upper St. Lawrence southwesterly, toward the basin of Lake Ontario and the great re-entrant angle of the glacial border at Salamanca in southwestern New York.

The trends of eskers and drumlins testify of the directions of the currents of the ice-sheet as trustworthily as the courses of glacial striation on the bed-rocks, with which the esker and drumlin ridges are parallel. Both these classes of drift accumulations, however, were formed near the border of the ice during its recession at the close of the Glacial period ; and they consequently often record local deflections of the glacial currents caused by unequal rates of melting and the resultant sinuosities of the ice-front. The Pittsford esker series, trending south-southeast, is nearly parallel with the general movement of the ice-sheet, both during the time of its maximum extent and thickness and during the decadence ; but the Pinnacle hills, trending west-southwest, show that a considerable local indentation or embayment in the waning ice-border there turned its currents much to the west from their former course.

Probable Origin of these Eskers.

Although these two esker series, lying only a few miles apart, differ about 90° in their trends, they were probably formed at the same time or one very soon after the other, as might happen by diversion of a glacial river from one avenue into another near its point of discharge from the ice-sheet. Each series seems to be attributable to deposition in the ice-walled channel of a stream of water flowing down from the surface of the melting ice-sheet, where the gravel and sand had been gathered from the previously englacial drift that had been exposed by ablation as a superglacial stratum. Near their mouths, or places of discharge to the land surface, these rivers appear to have flowed in valleys or gorges inclosed by unmelted plateaus of the ice-margin, upon which much drift rested. In some sections of our drift formations, as of Third and Fourth Cliffs in Scituate, Mass., which are partially eroded drumlins on the shore of the ocean, thick beds of stratified gravel and sand are found which were undoubtedly laid down by subglacial streams ([1]). But such beds formed under the ice-sheet are rare in most parts of the country, and the eskers here described and all others which have come under my examination of extensive areas in New England, and in Minnesota, northern Iowa, the Dakotas, and Manitoba, I believe to have been deposited in ice-walled channels open above to the sky.

Before proceeding to consider more in detail the structure and materials of these eskers in their bearing on this view of their mode of accumulation, it will be desirable to notice former expressions of opinion as to the origin of the Pinnacle hills. The earliest reference to this esker is by James Hall, in his report on the Fourth Geological District of New York, published in 1843. In pages 323 and 324 he gives a figure and description of the section where the ridge is intersected by Monroe avenue. "The gravel," Professor Hall remarks, "consists principally of waterworn fragments of the Niagara limestone, on which the whole deposit rests, and of the sandstones and limestones on the north. There are some boulders of the limestone, from two to four feet in diameter, worn perfectly smooth, or often striated with shallow grooves; and from the fact that this is the subjacent rock, they have received their rounded forms and smooth surfaces from attrition near the spot where we now find them." When this was written, the glacial theory of Agassiz had been published only a few years, and was not apprehended by Hall with such clearness as to seem adequate to account for this and our other drift deposits. It was observed that in this section "nearly all the strata dip towards the west," whence it was concluded that "the accumulation doubtless took place from

(1.) Proceedings of the Boston Society of Natural History, Vol. XXIV, 1889, pp. 228-242; Vol. XXV, 1891, pp. 228-242.

this direction, from the heaping of the coarse gravel upon the fine sand."

Mr. Charles R. Dryer, in the article before cited, calls both the Pinnacle hills and the Pittsford series kames, implying their deposition in the channels of glacial rivers. He especially notices that on the area where, if prolonged to the northeast and north, they would intersect, the valley of Irondequoit bay has been apparently filled with stratified sand and gravel to a height of 150 feet or more above the lake, as indicated by narrow terraces at such height left on each side of the bay. The level of the glacial Lake Iroquois during a late stage of its history, according to Mr. Gilbert, sank here considerably below the shore of Lake Ontario, and the depth of the Irondequoit bay suggests that the depression of this southern part of the glacial lake, permitting erosion of the former plain of modified drift in the Irondequoit valley, reached at least 80 feet beneath the present water level.

The discussion concerning the origin of the Pinnacle hills after the excursion to them last summer by members of Section E of the American Association was opened by Mr. Gilbert, who drew on the blackboard a sketch map of the esker series and the region about it and called attention to the narrowness of the east and west belts of outcrop of the several geologic formations. The Niagara limestone, occupying a belt that ranges from 2 to 7 miles in width through this part of New York, underlies the Pinnacle hills and much of the city of Rochester. Next northward the Clinton formation has a similar width, and beyond this the Medina sandstone outcrops on a somewhat wider belt which adjoins Lake Ontario. Each of these formations and the Archæan rocks of Canada are represented in the gravel and boulders of this hill range, and it is especially notable that usually the Niagara limestone is very plentiful, both as gravel and as boulders, which vary in size up to ten feet in diameter. Evidently this limestone drift can have been transported only a few miles, and its occurrence in the highest portions of the Pinnacle hills must be taken into account in inquiring how they were accumulated, for which, however, Mr. Gilbert had not framed any complete and detailed explanation.

Professor G. F. Wright and Mr. C. W. Hayes spoke of their own observations and those of Prof. I. C. Russell on glaciers in Alaska, where much superglacial drift is exposed on the wasting borders of the ice-fields and portions of it are washed away by rains and streams, which in most cases carry it finally into crevasses and subglacial water courses, like those of the Yahtse river and Fountain stream described by Russell as flowing out from beneath the Malaspina glacier. In these subglacial channels the streams must be building up eskers, while gently sloping gravel and sand plains are being deposited by the silt-laden waters in their course from the ice-front to the sea [1].

Professor E. W. Claypole drew a section of the marginal portion of the ice-sheet, showing how, in his opinion, the Pinnacle hills were formed by a stream which gathered drift from the melting ice surface, and then fell through a crevasse and deposited the sand, gravel, and boulders in a tunnel under the ice.

Following these speakers, I remarked that the absence of any covering of till upon the top and slopes of this esker, such as must have fallen upon it from the englacial and superglacial drift of its roof of ice if it were formed in a subglacial tunnel, leads me to believe that its stream was wholly superglacial, and that the esker was deposited in a deep ice-walled gorge, open above to the sky, eroded in the border of the ice-sheet by the melting action of the running water.

The purpose of the present essay will be completed by more fully considering the probable manner of transportation of the many boulders found in some portions of the gravel and sand of the Pinnacle hills, the relationship of this esker to the lower morainic ridge continuous from it westward, the abrupt eastward ending of the Pinnacle hills range, and similar features of the Pittsford esker series, with the inquiry constantly in mind whether these features support the view that these eskers were derived from previously englacial drift and accumulated in superglacial channels. It will be needful at the same time to consider the drainage from the ice-border in its relations to the glacial Lake Warren and to the beginnings of Lake Iroquois. Beyond this we ought to learn, if possible, whether the same explanation is generally applicable to eskers in other regions.

The leading reason for our special interest in the Pinnacle hills is the demonstrably near sources of their Niagara limestone boulders, which have been transported only a few miles and yet were uplifted at least 100 to 200 feet into the ice-sheet from an approximately plain country. Here we have a demonstration of the competency of the glacial currents to gather drift into the lower part of the ice-sheet from a nearly flat area, and we may understand how this takes place by the differential movements of the upper, middle and lower portions of the ice. Upon a belt of the ice-sheet extending many miles

(1). For description of the present process of formation of eskers and sand plains by rivers of the Malaspina glacier, see Russell's paper on "Mt. St. Elias and its Glaciers," Am. Jour. Sci., III, Vol. XLIII, pp. 169–182, with map, March, 1892 inward from the retreating margin, its surface had a considerable slope, so that the upper currents of the ice, unsupported on the outer side, would move much faster than its lower currents which were impeded by friction on the land. There would be accordingly within this belt a strong tendency of the ice to flow outward with somewhat curved currents, tending first to carry the onwardly moving drift gradually upward into the ice-sheet, and later to bear it downward and deposit it partly beneath the edge of the ice and partly along the ice boundary. The Niagara boulders, and others from the Clinton and Medina formations farther north, having been borne upward as englacial drift to a greater altitude than the Pinnacle hills, were exposed on the surface of the ice-sheet by its ablation and were swept by torrents bearing ice rafts, or probably sometimes by avalanches, into the river channel. Their great profusion in certain parts of this esker implies unusual abundance in and upon the contiguous portions of the ice-sheet, which may have resulted from convergent glacial currents and perhaps from a temporary re-advance of the thicker tract of the ice, massing its superglacial drift stratum in a way analogous with the accumulation of terminal morainic hills, which often are equally charged with boulders.

The morainic ridge continuing westward from the Mt. Hope cemetery seems probably to have been formed along the margin of the ice, on the northern side of a re-entrant angle or embayment into which the glacial river depositing the esker of the Pinnacle hills debouched. Close south of this ridge, a brick yard beside the Buffalo, Rochester & Pittsburgh railroad works the stratified clay which the river discharged into the shallow glacial lake of the embayment.

Finding so abrupt an end of this esker at Brighton, we are constrained to believe that the powerful river by which it was accumulated suddenly ceased to flow here. The neighboring Pittsford esker apparently shows the site of the new glacial channel, previously the course of some smaller stream, which then became the main avenue of drainage from the rapidly melting ice-fields of this region. But when the Pittsford esker had gradually grown in its length from the west flank of the Turk's hill range northward to the present site of Allen's creek, the glacial river which formed it was again diverted ; or more probably thenceforward it emptied into a marginal lake so broad and deep that no distinct esker was made, the gravel and sand being then laid down in the valley which now holds Irondequoit bay.

If the eroded drift from the area north of the Pinnacle hills was carried upward by glacial currents having an average ascent of one degree, it would rise within one mile 92 feet and within two or three miles would be higher than the tops of these hills. Currents ascending at this rate, or even two or three degrees or more, may very probably have existed in the lowest part of the ice sheet, on account of the acceleration of its upper currents, within distances from 20 to 50 miles or more back from its boundary. By these currents much drift eroded from the land surface would be gradually incorporated in the comparatively sluggish lower part of the ice, reaching altitudes 100 to 1,000 feet above the ground within a few miles from its sources.

It is also to be remarked that the rounded or at least subangular forms of the greater part of the pebbles and small rock fragments in the esker gravel do not necessarily imply wearing by the stream during a long transportation. Daubrée placed angular fragments of granite and quartz, ranging from the size of one's fist to that of a hazel nut, with water in slowly revolving cylinders and found that they became perfectly rounded when the revolutions amounted to 25 kilometers or about 15 miles. (1) Within a third of this distance probably some of the fragments had been well rounded, and in a less distance nearly all would be worn to subangular forms.

Many features of the modified drift, comprising glacial flood plains, eskers and kames, show that the melting of the ice-sheet at the close of the Glacial period was mostly very rapid. In the vicinity of Rochester it was hastened by the laving action of the glacial lakes on its southern border. Lake Warren had formed a beach which extends to the south side of the east end of Lake Erie, where its altitude is 860 feet above the sea. (2) At the time of formation of the Pinnacle hills and Pittsford esker series, the ice-border in New York appears to have receded so far that the water of the upper Laurentian lakes was no longer held up to the level of Lake Warren, which had outflowed at Chicago, and avenues of drainage seem already to have been opened eastward along the ice-border past the northern ends of the Finger lakes to the Mohawk valley. Undoubtedly the deposition of these esker gravel and sand beds took place above the level of such fringing lakes, which from the Genesee and Irondequoit basins could have no place of outflow eastward lower than by the way of Victor and Mud creek. The divide at Victor is somewhat higher than the general surface on which these eskers lie ; hence it seems probable that when the esker beds were laid down in their ice-walled channels a depth of some 100 feet, more or less, of ice still remained unmelted

(1.) Etudes Synthétiques de Géologie Expérimentale, 1879, pp. 248–250.
(2.) Bulletin, G S. A., Vol. II, pp. 258–265 ; Vol. III, pp. 484–487.

beneath them. In like manner I have shown that certain eskers in New Hampshire and Manitoba were underlain by ice at the time of their accumulation and by its melting away were afterward allowed to sink to the land. (1)

Application of this Explanation to Eskers elsewhere.

If eskers were subglacial deposits, we should expect them to be often covered wholly or partly with the englacial drift, as boulders and loose deposits of till, which would be permitted to fall upon them when the ice-roof was melted away. Such a roof would be more or less overspread with the drift that had been contained in the higher portions of the ice-sheet and was exposed on its surface by ablation. Sections indeed are occasionally found, where subglacial beds of modified drift have become covered by subglacial and englacial till ; (2) but these usually differ widely in their character from the torrential esker and kame deposits, which very rarely contain or bear upon their surface any considerable abundance of boulders or other drift materials that have not evidently been transported, worn, and assorted by water. In nearly all the localities where I have observed boulders or masses of till imbedded within eskers or lying on their surface, the most probable explanation of their derivation has been by falling from the enclosing ice-walls of channels open to the sky, or by being brought while frozen in ice-floes. (3) At only one place, in Dover, N. H., I have found a portion of an esker covered with a deposit of boulders and till which may have fallen from a melting ice-roof, though another interpretation seems to me preferable. (4)

A different view is taken by Professor W. M. Davis, who regards certain eskers in the vicinity of Auburndale, Mass., which I have repeatedly examined with him and other glacialists, as probably of subglacial origin. (5) These eskers I think to have been formed in ice-walled channels, open above and underlain by a slight depth of ice. Extending southward from them are associated sand plains or plateaus, deposited just outside the ice-front by the streams which produced the esker ridges. Professor Davis describes a backwardly dipping strati-

(1.) Geology of New Hampshire, Vol. III, 1878, pp. 107,116. Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, Vol. IV, for 1888-89, pp. 39-41 E.

(2.) Geology of N. H., Vol. III, pp. 108, 131-137, 289-291. Geol. and Nat. Hist. Survey of Minnesota, Eighth Annual Report, for 1879, pp. 113, 114 ; Final Report, Vols. I and II. Proceedings of the Boston Society of Natural History, Vol. XXIV, 1889, pp, 231-5, 237-9.

(3.) Geology of N. H., Vol. III, pp. 43, 46, 85, 88, 90, 92, 127, 145, 148, 158, 160, 162. Geology of Minn., Final Report, Vol. II, p. 550. Geol. and Nat. Hist. Survey of Canada, Annual Report, Vol. IV, pp. 40-42 E.

(4.) Geology of N. H., Vol. III, p. 159.

(5). Bulletin, G. S. A., Vol. I, pp. 195-202, with sections. Proceedings of the Boston Society of Natural History, vol. XXV, 1892, pp. 477-499.

fication of the beds forming the edge of the plains where they adjoined the ice-sheet, and attributes it to the upflow of subglacial waters bringing with them the sediments which make the plain and reach to a considerable distance, having in their lower portion, on the greater part of their area, the forwardly dipping stratification that is characteristic of deltas or of deposits swept by torrential currents into the slowly flowing broad expanse of flooded rivers. It seems to me, however, more probable that the back-set beds were formed by the downward and backward transfer of sand from the surface of the plain, to fill in succession the small spaces from which the ice-sheet was gradually withdrawn.

Because the summer melting of the North American ice-sheet in the Champlain epoch, or closing stage of the Glacial period, was far more rapid than that of the Alaskan glaciers at the present day, the previously existing small subglacial stream-courses were inadequate for the transportation of the large supplies of englacial drift then set free, by which, indeed, the subglacial tunnels appear to have been mostly obstructed and closed. The waters of the glacial melting and of accompanying rains therefore flowed, as I believe, in channels on the ice surface, often near their mouths more like cañons than like ordinary land valleys, there depositing the eskers and kames.

My studies of the Pinnacle hills and Pittsford esker series, of the very massive kame deposits forming the greater part of the outermost terminal moraine on Long Island eastward from Roslyn (1), of the large kame called the Devil's Heart, rising in a somewhat conical hill 175 feet above the adjoining country south of Devil's lake in North Dakota, and of the esker named Bird's hill, seven miles northeast of Winnipeg (2), seem to me to demonstrate, beyond all doubt, that their material, and probably likewise that of eskers and kames generally, was supplied by superglacial streams from the plentiful englacial drift, and could not have been brought from drift beneath the ice by subglacial drainage.

(1). Am. Jour. Sci., III, Vol. XVIII., pp. 84-88, Aug., 1879.
(2). Geol. and Nat. Hist. Survey of Canada, Annual report, new series, Vol. IV, for 1888-89, pp. 38-42 E, with section.

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