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CONTENTS OF BROCHURE 3 OF VOL. II.

SCIENTIFIC PROCEEDINGS.

JANUARY 23, 1893.

STATED MEETING.

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

About one hundred persons present.

The first lecture of the Popular Lecture Course was given by MR. FRANK D. PHINNEY, entitled :

LIFE AND SCENES IN BURMA.

The lecture was illustrated by a large number of lantern views of natural scenery and products ; the people, their villages and handiwork ; images, objects and places of worship ; the monasteries, pagodas and their surroundings.

FEBRUARY 13, 1893.

STATED MEETING.

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

Forty-five persons present.

The Council report recommended :

(1.) The payment of a bill for Secretary's expenses.

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

DR. J. E. BISSELL,
DR. CHARLES F. HOWELL,
MRS. E. L. MAGUIRE,
MR. WILLIAM W. PARCE.

The bill was ordered paid, and the candidates were elected by formal ballot.

DR. LEWIS SWIFT delivered an astronomical lecture entitled

OVERHEAD.

A vote of thanks was given the lecturer.

FEBRUARY 27, 1893.

STATED MEETING.

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

One hundred sixty persons present.

The second lecture of the Popular Lecture Course was delivered by PRESIDENT DAVID J. HILL, of the University of Rochester, entitled :

THE ETHNOGRAPHY OF THE PACIFIC ISLANDS.

The lecture consisted of a sketch of the physical geography of the Pacific Islands and a description of their flora and fauna, with an account of the arts of life and social customs, illustrated with lantern slides.

MARCH 13, 1893.

STATED MEETING.

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

Forty-five persons present.

The Council report recommended the election as active members of MR. and MRS. GEORGE C. BUELL. The report was adopted, and the candidates were elected by formal ballot.

The Librarian, MISS MARY E. MACAULEY, announced the addition of one hundred fifty titles to the library.

The following paper was read :

NOTE ON THE CLASSIFICATION OF SURDS AND IRRATIONALS.

BY PROFESSOR ARTHUR LATHAM BAKER.

Under the head of SURDS, the typical statement of the text books is—"If the root of a quantity cannot be exactly obtained, the indicated root is called a *Surd* or *Irrational Quantity*."

To make the inference doubly sure, that Surd and Irrational Quantity are synonymous terms, some add—"Quantities which are not surds are termed rational quantities."

The same confusion is noticeable in dictionaries, encyclopedias, and text books, and even in the latest authority, the Century Dictionary, where surds and irrationals are treated as synonymous terms; and I know of no text book where the same errors are not noticeable.

The fallacy of this definition and the necessity for a clear distinction between the terms is shown in the theorem which always closely follows, viz.—The square root of a rational quantity cannot be partly rational and partly a quadratic surd (*irrational*). The parenthesis and italics are mine.

The proof to the contrary, objectively put, is

$$\sqrt{3} = 1.732 \ldots. = 1 + 0.732 \ldots.$$

which shows that a quadratic surd *is* equal to a rational quantity plus an irrational quantity.

The truth is that the irrational part is a pure irrational which has not the properties of a large class of irrationals to which some distinctive name should be given, preferably that of *surd.*

The correct analysis and definition should be:—

Irrational or incommensurable numbers are divided into *Surds* and *Non Surds.*

Surds are the indicated or incommensurable roots of commensurable quantities, such as, $\sqrt{3}$, $\sqrt{2}$, etc.

Non Surds are the indicated or incommensurable roots of incommensurable numbers, *i. e.*, all irrationals which are not surds, as

$$\pi = \sqrt{\pi^2}, \quad \pi^2, \quad \sqrt{\sqrt{3} - 1} = 0.732 \ldots., \text{ etc.}$$

It may be that non surds are transcendentals which can not be graphically represented by the ruler and compass as can the surds, $\sqrt{2}$, $\sqrt{3}$, etc.

NOTE. Since this paper was read, Dupuis' Algebra and Van Velzer and Sclichter's Algebra have appeared in which the distinction here suggested has been made. So far as I know, other text books conservatively adhere to the erroneous definition, though several years ago the attention of a number of authors had been called to the error.

The following paper was then read by MR. JOSEPH E. PUTNAM:

DISCUSSION OF SOME PRACTICAL POINTS ABOUT ELECTRIC MOTORS.

The paper was illustrated by experiments.

MARCH 27, 1893.

STATED MEETING.

Vice-President, DR. M. L. MALLORY, in the chair.

A large audience present.

The third lecture of the Popular Lecture Course was delivered by PROFESSOR H. F. BURTON, of the University of Rochester, entitled :

THE ARCHITECTURAL SPLENDOR OF ANCIENT ROME.

The purpose of the lecture was to give an impression of the grandeur of the ancient city of Rome at the time of its highest development. Stereopticon views were shown representing various buildings in Ancient Rome in their original form, so far as can be ascertained. These representations were derived from the works of eminent archæologists, such as Canina, Piranesi, Bühlmann and others. Among the objects represented were the walls and gates of the city ; the Roman Forum ; the temples of the Capitoline hill ; the palaces upon the Palatine ; the Fora of Julius Cæsar, Augustus and Trajan ; the Pantheon ; the theatre of Pompey ; the Colosseum ; the Circus Maximus ; the baths of Caracalla and Diocletian ; and, finally, the roadside tombs and the imperial Mausolea.

The lecturer said in part : "It is difficult for us to conceive of the magnificence of Rome for two reasons : because there exists no modern city with which it can properly be compared, and because the remains of Ancient Rome are so scanty, so bare and ugly, that to the ordinary observer they suggest nothing but ruin and decay."

"The beauty of the city of Rome was due to three causes, namely : to its location, to the material used in its buildings, and to the architectural skill employed in their construction."

"The site of Rome had the advantage of great variety of elevation, presenting an alternation of steep hills and low lying valleys, of level plains and gradual slopes. Its hills were crowded with palaces and temples, and the observer who stood upon them beheld the city itself, spread out like a map before him, and might look far down the Tiber valley to the sea, or across the level country to the snow-capped mountains."

"The building materials used in Rome were at first rough volcanic rock and limestone in huge blocks ; later, concrete faced with red brick ; and, finally, marble and granite of every variety ; white marble from Greece and the islands of the Aegean Sea ; mottled pink and brown marbles from Asia Minor, yellow marbles from Africa, and gray and red granite from Egypt. Bronze was extensively used for temple doors and as a covering for roofs, and was frequently overlaid with gold."

"The Romans borrowed from their neighbors whatever architectural forms they found suited to their own needs. They learned from the Etruscans the principle of the arch, and employed it extensively in all its forms, the simple arch, the vault, and the dome. From the Greeks they obtained the colonnade with its three orders of columns, Doric, Ionic, Corinthian. But the Romans were not content to borrow only ; they combined the arch and the colonnade in a great variety of forms with fine decorative effect. They displayed in their architecture great practical originality in the application of known principles and methods in the development of new architectural types."

"This survey of the great structures of Ancient Rome suggests the regret that such splendid works of architecture should have disappeared from the earth. But the wealth of Rome, which made possible its magnificence, was gained not by honest industry, but by conquest and plunder ; when, therefore, Roman imperialism went down, making way for modern liberty, it was fitting that the gorgeous palaces that had housed it should fall into ruins. That which was best in Rome has survived. We have her literature and her history, her system of government and jurisprudence, and we need not lament the loss of her marble and bronze."

April 10, 1893.

STATED MEETING.

The meeting was held in the Geological Lecture Room, Sibley Hall, University of Rochester.

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

Twenty-seven persons present.

The Council report recommended that $50.00 be appropriated to cover the expenses of the Popular Lecture Course, the bills to be approved by the President and Secretary.

The report was adopted, and the appropriation made.

Thc following paper was read by the President:

THE EVOLUTION OF THE UNGULATE MAMMALS.

By Herman Le Roy Fairchild.

(Abstract.)

This group of mammals was divided by Cuvier into two orders, the Ruminants and the Pachyderms. The living Ruminants form a very distinct group, marked by persistent features, namely, horns and hoofs in pairs, upper incisors wanting, stomachs complex, and the habit of rumination. But it was found that the fossil representatives of these orders did not fall into such a classification, and Professor Owen showed that the foot structure was a more persistent and fundamental distinction. The order Ungulata, as now constituted, includes the mammals formerly classed as Ruminants and Solidungula, and all those formerly called Pachyderms, except the Proboscidians. Of the larger mammals, both extinct and living, this is the most numerous and comprehensive order.

The members of this order walk on the extremity of the toes, which are protected or encased in a greatly expanded nail or hoof (ungula). This apparently superficial character is but one element in the structure of the ungulate foot, which structure is of the utmost value in tracing relationship of the fossil mammals, and the study of it forms one of the most fascinating chapters in Comparative Anatomy.

The number of digits of full size never exceeds four, at least the first digit being always obliterated. As the limbs are used only for locomotion, never for prehension, clavicles are useless and therefore wanting. The molar teeth are massive, with broad crowns suited for grinding vegetable food, although the primitive species were probably omnivorous, like a few living forms. The brain is proportionately small, and the food canal unusually long.

The Ungulates were the most numerous and important mammals of Tertiary time, and those ancient species were the ancestors of the present specialized forms, the line of descent being clearly traced in some cases, especially in the horse, the most highly differentiated species.

The division of this order, proposed by Owen, into Artiodactyla (even-toed), and Perissodactyla (odd-toed), applies to the extinct forms, which as early as the lowest Eocene were thus separated, notwithstanding their generalization in other respects. The present tendency of the study is to regard the Artiodactyla and the Perissodactyla, not as constituting one order, but as two parallel series derived from the Condylarthra of Cope, the primitive type of hoofed mammals. *Phenacodus*, found at the base of the Eocene in America, having a small brain, five toes and tuberculated molars, possesses characteristics which point to the primitive ungulate type.

In the evolution of the present Ungulates there are two elements of special interest. The primitive ancestors of the order were probably omnivorous, like the existing pig, with tuberculated (bunodont) molars. But the specialized forms, as the horse of the odd-toed, and the ruminants among the even-toed, have developed molars better fitted for grinding, which have the enamel disposed on the effective surface in double crescents (selenodont dentition), whose convexity is turned inwards in the upper teeth and outwards in the lower. The other factor in the evolution was the relation of the small bones of the wrists and ankles to the surviving digits. In the loss of the side digits, and the enlargement of the central ones, it became necessary for the latter to either appropriate the carpal or tarsal bones belonging to the side digits, or for their own small bones to become properly enlarged. Nature employed both methods; but it has been shown by Kowalevsky, the Russian naturalist, that the first or appropriative method was the better, and that all the species in both sections in which the latter (inadaptive) plan occurred have become extinct.

The lacustrine deposits of the Rocky Mountain region have furnished great variety and numbers of Tertiary ungulates, which have been studied by Leidy, Cope, Marsh and Scott. They have found that all the existing genera of Perissodactyla, and the Camel and Peccary among Artiodactyla are true American types, and might have populated the Old World by migration.

ARTIODACTYLA. In this division the digits are four or two in number, and the axis of the limb passes between the third and fourth, which make a symmetrical pair, and by their compressed form have suggested the term "cloven-footed." The femur has no third trochanter. The dorso-lumbar vertebræ are usually nineteen. The true horns are in transverse pairs, with osseous horn-cores. The antlers of the *Cervidae* are themselves osseous, and deciduous, and are not regarded as true horns. The stomach is complex and the cæcum small The hornless species have usually long canines. Some extinct forms as *Oreodon* and *Hyopotamus* had five digits on the fore foot.

Among larger mammals, now living, this division is the most numerous, and is extensively represented in the Tertiary, beginning with the Eocene. The species were few in the Eocene and included no ruminants. The earliest were apparently the ancestors of the Hogs, and had the tubercular (bunodont) dentition, which was common in the Artiodactyla through all the Tertiary, but is now found only in the Hogs and Hippopotami (non-ruminants).

The selenodont dentition is found in the upper Eocene, but a primitive or transitional form occurred in *Homacodon*, which lived in the middle Eocene, having a nearly continuous series of teeth, and the typical number, 44.

The two plans of foot structure are found in the Tertiary with both kinds of dentition, but no species survive with the "inadaptive" plan.

The Camels and Llamas diverged from the primitive stock in the Eocene, and became in the Pliocene the most abundant of the larger animals, except the Horse family. The hollow-horned ruminants appeared in Europe in the Miocene, but have not been found in America earlier than the Pliocene.

The true Sheep, Goats, Giraffe, Hippopotamus, and Old World Suillines (*Sus*, *Porcus*, *Phacochœrus*), have not been discovered in America. The Suilline type, the most generalized of the Artiodactyla, and with bunodont dentition, began in America in the lower Eocene, and has been abundant ever since, being now represented by the Peccaries.

PERISSODACTYLA. These are the oldest and most abundant ungulates of the Eocene, and as a group are less specialized than the Artiodactyla, although the Horse, in feet and teeth, is the most highly differentiated species. In all the living species the hind feet have an odd number (3 or 1) of toes, and the Tapir is the only one with an even number (4) on the fore feet. The axis of the limbs passes through the third digit. In living species there are never less than twenty-two dorso-lumbar vertebræ, the femur has a third trochanter, and the horns, if present, are placed on the median line of the head, and are not supported on horn cores. In the extinct *Titanotherium* there are a pair of horn cores placed transversely. The stomach is simple and the cæcum large.

There are but three families now living, represented by the Horse, Rhinoceros, and Tapir, but these are closely connected by numerous extinct forms. Cope enumerated (1883) one hundred and ninety-two species, of which nineteen are living. He regards his *Systemodon* and *Ectocion* as parent types.

The complete pedigree of the Horse has been traced by Marsh, from the little *Eohippus*, of the lower Eocene, with four toes and the rudiment of the first on the fore feet, and three on the hind feet, through seven intermediate genera of successive horizons in the Tertiary, to the modern genus, *Equus*, in the upper Pliocene. *Miohippus*, from the lower Miocene, resembles *Anchitherium* Leidy, and *Protohippus* of the upper Miocene most resembles *Hipparion*. Marsh finds some forty extinct species in this group. It is certain that the horse originated in America, and roamed over both continents in Post-Tertiary time, and then for an unknown reason became extinct.

The *Paleotherium* is closely related to the early members of the Horse family, and Cope includes here some of the supposed ancestors of the horse. The family is entirely extinct since the Pliocene.

The Rhinoceros family has many representatives and a long line of ancestry in the Tertiary. *Cœnopus* from the Miocene of America is the earliest member of the family, of which there seem to have been two branches. *Diceratherium* had a transverse pair of horns on the nasal bones. Several species are found in American Pliocene, but none later. The living species have three toes on each foot, and horns on the median line.

The Tapirs constituted another family of American origin. It began in the Eocene, and exists to-day in South America and East India. They have three toes on the hind feet, with four on the fore feet, but the axis of the arm passes through the third digit. It is the most generalized type of living Perissodactyla.

The *Titanotherium* family is found only in the upper Eocene and lower Miocene of the American lake-beds.

Of the Lophiodontidæ Cope enumerates fifty species, all from the Eocene of America and Europe. They vary in size from that of a Rabbit to that of an Ox, and resemble most, among living aaimals, the Tapirs.

The paper was illustrated by exhibition of fossils and lantern views.

April 24, 1893.

STATED MEETING.

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

Seventy persons present.

The fourth lecture of the Popular Lecture Course was delivered by Professor Lester F. Ward, of the U. S. Geological Survey, Washington, D. C., entitled :

THE VEGETATION OF THE ANCIENT WORLD.

The lecturer began with some remarks on the age of the different fossil forests, illustrated by the lantern views, using some of the estimates that have been lately made by eminent geologists as to the number of years that have elapsed since the beds containing the fossils were deposited. The lecture consisted of an explanation of some thirty views thrown on a screen, representing in chronological order the several floras that paleontology has revealed, beginning with the Devonian, as illustrated by Dawson, showing the great Carboniferous flora, chiefly from views from Heer and Gran d'Eury, then passing up through the Mesozoic and Tertiary to the Pleistocene. The Mesozoic and Cenozoic ages were largely illustrated from American specimens that have been figured in the works of Fontaine, Lesquereux, Newberry, and the lecturer.

May 8, 1893.

STATED MEETING.

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

Seventy persons present.

The report of the Council recommended :

(1.) The payment of certain bills.

(2.) The election of Dr. Daniel G. Hastings as an active member.

The report of the Council was adopted and the candidate was elected by formal ballot.

The following paper was read :

BACTERIA AND THE PUBLIC HEALTH.

By Professor Charles Wright Dodge.

The lecture, which was popular in its nature, was introduced by a brief glance at the yeast plant, which in its structure and some of its habits bears a general resemblance to bacteria. The morphological and physiological means of classification of bacteria were mentioned, then the various points of structure, the functions of the different parts and the methods of reproduction were discussed. The conditions of life as shown by the relation of bacteria to moisture, air, temperature, food supply and light were reviewed, and mention made of the products of the vital activities of bacteria, *e.g.*, fermentation, putrefaction, nitrification, and the formation of gases and pigments, and the exhibition of fluorescence and phosphorescence. Some of the methods by which bacteria are studied were illustrated, and the special apparatus used in bacteriological investigation exhibited and explained. The lecturer then passed on to a general discussion of these organisms in their relation to man, taking up briefly the topics of dust and ventilation, water supply, filtration and sewage, clothing, food, social customs, etc., as sources of infection. A hasty glance at certain common diseases as diphtheria, tuberculosis, typhoid fever and cholera was then made, the reasons given for considering such diseases of bacterial origin ; some of the possible sources of infection named, and precautions given to assist in avoiding infection.

The lecture was illustrated by charts showing the structural features of various forms of bacteria ; by a large number of pure cultures on various nutritive media to show characteristic growths ; by mixed cultures made by exposure of culture plates to air, water, etc.; and by cultures made from various foods, and from books, money, clothing, etc., etc. Microscopic preparations of pathogenic and non-pathogenic bacteria, and sections of infected tissue were shown. The various utensils and pieces of apparatus used in a bacteriological laboratory were also exhibited.

The paper was profusely illustrated by cultures of bacteria, microscopical slides and bacteriological apparatus.

JUNE 12, 1893

STATED MEETING.

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

Ten persons present.

The Council report recommended the payment of certain bills. The report was adopted and the bills ordered paid.

Upon motion the Rules were suspended, and PROFESSOR LESTER F. WARD was elected an Honorary Member.

Dr. M. A. Veeder spoke of the Foucault pendulum experiment, and its relation to the movement of storms.

After discussion, it was voted to appoint a committee of five members to conduct a pendulum experiment in Rochester with a non-magnetic wire. and at a limited expense.

The following committee was appointed: Dr. M. A. Veeder, Prof. A. L Arey, Prof. A. L Baker, Mr. Arthur L. White, Mr. William Streeter.

Dr. M. A. Veeder made a report upon the subject of auroras and the observation of auroral phenomena. He spoke of the preparation made by Lieut. Peary and others to take observations in high latitudes and the coöperation of foreign governments, notably the Scandinavian and Russian, and stated that a mass of material had been accumulated in this line as a result of action initiated by this Society.

OCTOBER 9, 1893.

STATED MEETING.

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

A small number of persons present.

The Council report recommended the payment of certain biils, which were ordered paid.

HON. MARTIN W. COOKE read a paper on

THE FIGURE OF THE EARTH.

(Abstract.)

The figure of the earth is due to the constant action of forces which determine the pressure of the particles constituting the globe. It is the same that it would be if the earth were composed entirely of water. Such a globe of water affected only by its own gravitation would assume the form of a perfect sphere. Its rotation would bring into operation another force called centrifugal force. Both these forces act upon each particle separately—gravitation drawing it towards the centre of the globe and the other force urging it away from its own centre of gyration in the direction of the radius. At the equator the centre of gyration is the centre of the earth and the operation of the centrifugal force is there in direct opposition to the earth-pull. In every change of latitude along any meridian there is a change in the direction in which the force of gravitation, or earth-pull, acts upon the particles; but the direction in space in which the centrifugal force urges them does not change, for the centres of gyration change along the axis with every change of latitude.

The intensity of the earth-pull, affecting particles of the same mass, varies slightly by reason of the ellipticity of the earth from the equator along any meridian to the pole; but the intensity of the centrifugal force varies as the cosine from maximum, at the equator, which is about one two hundred eighty-ninth of the earth-pull, and vanishes at the pole. Inasmuch as the earth-pull changes from opposition at the equator for every change of latitude, the weaker force (the centrifugal) is resolved—one component acting vertically, or in direct opposition to the earth-pull, and the other at right angles to it and towards the equator.

It was claimed that the earth-pull upon a particle at the 60th parallel of latitude minus the vertical component of the centrifugal force affecting the same particle, plus its horizontal component, constitutes a combination of forces greater than any affecting particles upon any other parallel of latitude. The force so combined with that of the earth-pull is .366 of the whole centrifugal force of a particle at the equator; at the 30th parallel the vertical component of the centrifugal force of a particle is equal to the horizontal component and one counteracts the effect of the other in its pressure. At the 70th degree the difference between the horizontal component and the vertical, in favor of the horizontal, is equal to .3 of the centrifugal force of a particle at the equator. The equilibrium is maintained by the difference of level. The shallower vertical plane at the 60th parallel sustains the deeper planes at the other degrees of latitude.

It was contended that the pressure of a particle at the surface, under the influence of these three forces, is represented by the earth-pull minus the vertical component plus the horizontal component while equilibrium obtains. It was conceded that if the centrifugal force should act at all points vertically, or in direct opposition to the earth-pull, or if the whole force should act at right angles to it, the globe would asume the form of an ellipsoid ; but it was shown that none of these conditions obtains. The reader maintained that the greatest pressure in the vertical plane is at the 60th parallel of latitude and that such pressure varies but slightly between the 70th and 40th degrees of latitude. From the 40th parallel it diminishes rapidly, with a corresponding rise of the surface, to the equator, and from the 70th parallel it diminishes to the pole. The argument was that the shape is maintained by the varying pressures in the different vertical planes, and is higher or lower as this pressure is weaker or stronger ; and, consequently, that the shape of the surface of the earth between the 70th and 40th parallels is very nearly that of a sphere but with the lowest point at the 60th parallel. The shape is maintained by this varying pressure—the bulging at the equator commencing in both hemispheres at the sixtieth parallel of latitude.

October 23, 1893.

STATED MEETING.

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

Forty persons present.

Remarks regarding scientific observations made during the previous summer were made by Dr. E. V. Stoddard and Mr. F. W. Warner.

The death was announced of Mr. George H. Harris. Upon motion of Dr. Stoddard the President was authorized to appoint a committee to prepare resolutions upon the death of Mr. Harris.

The President subsequent to the meeting appointed as the above committee, Mr. S. A. Ellis, Mr. Adelbert Cronise, Mr. H. C. Brewster.

The following paper was read :

THE GEOLOGICAL HISTORY OF ROCHESTER, N. Y.

By Herman LeRoy Fairchild.

To interpret from the rocks the long geological story of this locality some fundamental geological principles must be clearly in mind.

The vast majority of all sedimentary rocks (to which group belong all those of Rochester, except the superficial drift) are layers of detritus formed in the sea, and derived from the decay and wash of neighboring land. Such accumulations are possible through the oscillations of level, which may slowly carry great continental areas under the sea, to re-elevate them, probably, at a later time. The thickness of strata may bear a direct relation to the amount of subsidence. This does not signify that the continental areas and the oceanic basins ever change places, but simply that submerged areas of a continent are no less part of the geological continent in that they lie below sea level. Whether or not a portion of the continent be dry land depends upon slight changes of attitude toward the plane of water surface.

The character of sediments indicates the conditions under which they were formed. A gravel deposit means strong currents and consequently shallow water, and a near source of supply. Finer material, as sand, indicates less velocity of water, probably greater depth and greater distance from land. A pure quartz sand indicates a great amount of movement, immediately or remotely, necessary to remove by trituration, assorting and solution the other minerals of the original crystalline composite rock. A stratum of shale (indurated silt) can be deposited only in slack water, and if of great horizontal extent indicates considerable depth of sea and probably long transportation.

Shallow water deposits are frequently marked by sinuosities due to waves. Exposure above water at low tide is shown by several features, as shrinkage-cracks, rill-marks, rain-pits. A near shore-line is proven by cross or oblique bedding, and other phenomena produced by variable currents due to changing winds and tides. Climatic conditions, and to some extent depth, are indicated by the nature of the organic remains.

Limestone rocks are produced by the comminution of the calcareous framework of low organisms. Such rock may be formed upon the place where the animals grow, the detritus mingling with the larger masses, as in the coral limestone now forming upon reefs in tropic seas, requiring pure water and violent wave action ; or the detritus may be far borne by currents and left as a fine, structureless, organic sediment. If derived from the destruction of older limestone rocks, the lime sediment may be mingled with other silt in any proportion.

Aqueous sediments of volcanic origin are distinguished by their mineralogic character, and deposits entirely of meteoric origin are confined to ocean areas far from land.

Beneath the city of Rochester the drill has penetrated to a depth of over 3,000 feet, giving us fortunately a section ([1]) of the underlying strata down near to the crystalline base. From the character of these rocks we may read the main events in the history of this locality since Archean time, for even geological history with its "millions of years" has its early period of the unknown. What the local conditions were during Archean and Algonkian time, a duration as great, perhaps, as all time since, we can only conjecture. This area may have been a portion of the early land mass, which supplied by its destruction the material for Archean strata or from the earliest time it may have been continually under the continental sea.

The following table gives the Rochester strata in order of superposition, the oldest at the bottom :—

Condensed Section of the Rochester Strata.

Magnesian limestone	60+	feet,	Niagara Group.
Dark shale	80	"	" "
Limestone and shale partings	18	"	Clinton Group.
Green and purple shale	24	"	" "
Limestone	14	"	" "
Green shale	24	"	" "
Red sandstone and shale	1075	"	Medina Group.
Blue and gray sandstone	83	"	" (Oneida) Group.
Dark shale	598	"	Hudson-Utica Group.
Dark limestone	954	"	Trenton Group.
Gray limestone	40	"	Calciferous Group.
Dark shaly limestone	50	"	" "
Black magnesian limestone	44	"	" "
Dark calcareous shale	3	"	" "
White siliceous magnesian limestone.	2	"	(?)
Ferruginous quartz	(?)		(?)

(1) The record of this well is published in detail in these Proceedings, Vol. 1, pp. 182–186. "A Section of the Strata at Rochester, N. Y., as shown by a deep boring." By H. L. Fairchild. Republished with notes in article by C. S. Prosser in this Volume, pp. 91–92.

Beginning with the oldest legible record, we have a white granular calcareous rock, [2] which in age may be Calciferous, or the previous Cambrian, or, possibly, the still earlier Archean. The uncertainty arises from our lack of information as to subjacent rock which was only touched by the drill. Under the microscope the grains of this siliceous limestone rock appear rounded or water-worn, the effect of the grinding, transporting and assorting power of water, and indicating detrital origin. This sand was deposited in not very deep sea, nor very far from land, which was probably somewhere to the north or northeast. The particular conditions did not exist long, for only some two feet of this limestone was laid down. Then there came a deepening of the water, and withdrawal of the shore-line, or else by the interposing of some barrier to the currents the latter were checked or diverted. These changes in the geography may be regarded as inaugurating a new geologic period, the Canadian or Calciferous. The sediment became a silt (now indurated into a calcareous shale) being the finer portion of some land-derived detritus mingled with some calcareous matter. It reached only the small depth of three feet when the oceanic conditions of the locality were intensified, and the sediment became nearly pure lime, the land silt being excluded. This dark limestone accumulated to a depth of 44 feet. Then the changing geography again allowed some silt to reach the area, and 50 feet of dark gray, clayey limestone accumulated. Again the silt was excluded, and 40 feet of pure, drab-colored limestone were formed. These Calciferous beds, consisting of 134 feet of variable limestones resting upon a thin base of shale, represent marine conditions, with the exclusion of strong currents bearing coarse detritus.

Concerning the life history of this period we have knowledge from the fossils of the same geologic horizon accessible at other localities. If any vertebrates lived they have not been found. But below the vertebrates there was a profusion of animal life representing all the great marine groups. Crustaceans were abundant, chiefly trilobites. Mollusks predominated, especially brachiopods. Plants so far as known, were wholly marine.

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(2) In the well-record as originally published (see foot-note above) this rock was called a sandstone. An analysis of the sample (63), which contains some black shale derived from the stratum next above, made by Mr. V. J. Chambers of the University of Rochester, gives the following:—

Insoluble in hydrocholic acid,		63 per cent.
Soluble in hydrochloric acid—		
$CaCO_3$	20.93	
$MgCO_3$	14.08	
Residue	1.99	37 per cent.
		100 per cent.

Following the Canadian period was an epoch called the Trenton, during which the sea-bottom here was slowly sinking, thus permitting the accumulation of a great limestone terrane. Organic growth and decay during a vast time is represented by 954 feet of dark limestone. Roughly estimating from the present growth of coral reefs, this limestone of the Trenton would require 190,000 years. It might have taken a much greater time. Plant and animal life was slowly changing, and the oldest known fishes, the first vertebrates, are found in this horizon (3) in Colorado.

The close of the Trenton and the beginning of a new epoch was determined by such change in geographic features as to throw open this region to wash of land, thus stopping the growth of lime-producing organisms and the accumulation of limestone, and producing instead a deposition of silt or clay. In New York terminology, this epoch is known as the Hudson or Hudson-Utica (the names indicating localities where the strata are found at the present surface), and is represented here by 598 feet of dark-colored shales, which required for their accumulation a vast duration. The Trenton limestone terrane and the Hudson shale terrane, together representing the Trenton period, are both widely developed, eastward to the Hudson river, and westward through the Mississippi region, indicating that the marine conditions were widely uniform in those early times, and that the source of silt supply, or the dry land, was probably to the north.

The close of the Trenton period is the end of the great age of the Lower Silurian, which includes all the formations thus far considered. The transition is marked here by the change from silt to sand deposit due to shallowing of the sea, but this locality was not lifted entirely out of water as were areas in the east. The next formation is 83 feet of gray and blue shaly sandstone belonging to the Oneida or Oswego epoch and regarded as the base of the Medina, from the fact of its local character.

The Oneida epoch and all the subsequent time represented by our strata are included in the Niagara period of the Upper Silurian age. But the strata are various and important, and mark minor time divisions. The blue-gray sands of the Oneida were soon buried beneath the dark red sands of the Medina. Over 1,000 feet of this sediment accumulated, of which the uppermost 100 feet shows in the lower Genesee ravine. The Medina beds indicate wide-spread

(3) Bull. Geol. Soc. Amer., Vol. 3, pp. 153-172. "Preliminary Notes on the Discovery of a Vertebrate Fauna in Silurian (Ordovician) Strata," By C. D. Walcott.

shallow waters, a slowly subsiding sea bottom, and the degradation of some land area of iron-bearing rocks, which should supply the peroxide of iron that gives the red color. This is a remarkable formation in composition, thickness and extent. The conditions seem to have been such as are usually transitory, but which in this case persisted for a vast time over considerable area. The shallow depth was here preserved by slow subsidence, although slight changes of conditions produced variations in the texture of the rock.

The deposition of the red Medina sands ended with remarkable abruptness, and subsequently, whether immediately or not is uncertain, a fine greenish silt was filtered over the bottom, and this continued until in this locality 24 feet were accumulated. Probably this indicates a sudden increase of depth. By some physical change the velocity of the currents over this locality was certainly checked, either by increase of depth or by the raising of barriers. This shale, called the Lower Green Shale of the Clinton, terminated as abruptly as it began. The argillaceous was replaced by calcareous sediment, and 14 feet of limestone accumulated, the Lower Clinton (or Pentamerus) limestone. These sudden and frequent changes of sedimentation, from siliceous to argillaceous, from argillaceous to calcareous, or the reverse, are difficult to explain for want of knowledge as to the physical conditions of the surrounding regions.

Near the base of the Lower Clinton limestone occurs a bed of hematite iron ore of singular character. It is about a foot in thickness, chiefly pure peroxide of iron, more or less minutely concretionary, fossiliferous, and probably accumulated upon the sea-bottom as a sediment. ([4]) In other areas of the Clinton the ore may have a different horizon or position in the succession of beds, and in some localities it is of considerable thickness. The source of this iron is unknown. ([5])

When the lime deposition gave place to silt another 24 feet of greenish clay were formed. In this Upper Green Shale of the Clinton there are found at one horizon lenticular masses of pure limestone wholly composed of the consolidated shells of a tiny Brachiopod mollusk (*Leptocœlia*) which formed colonies at certain spots upon the muddy sea bottom. These masses of molluscan limestone are exceedingly interesting, and clearly prove and illustrate the organic

(4) "On the Clinton Iron Ore," by C. H. Smyth, Jr., Amer. Jour. Sci., Vol. XLIII, pp. 487-496.

(5) All these strata, from the Medina upward, are clearly shown and are accessible for examination along the old road known as Buell Avenue, north of Seneca Park bridge, below the lower falls, west side of the ravine.

origin of the rock. The lens-like masses sometimes blend horizontally and form an irregular thin stratum, making what Dr. James Hall fifty years ago named the "Pearly Layer." ([6])

Again the silt gave place to limestone, but the change was gradual and not complete. Thin beds of limestone with layers of silt intervening make the 18 feet of the Upper Limestone of the Clinton group. With the lime accumulation there was considerable silica, and masses of chert are found and siliceous replacement of the fossils.

The Clinton epoch in time is thus represented here by alternating strata, two strata of shale and two of limestone, all requiring deep or comparatively quiet waters. The alternation of muddy water, producing silt deposit, and clear water, allowing limestone accumulation, became in the Upper Limestone rapid and sudden changes, apparently not dependent upon changes of depth, but upon varying direction of the sea currents. When the currents reaching this locality came from near some land the detritus was swept in and shale accumulated, but a change in the direction of the currents bringing in the wash from some coral reef or limestone beach permitted the calcareous accumulation.

From the limestone and silt of the Upper Clinton, the change was to a coarser silt or arenaceous clay. Of this firmer shale 80 feet were deposited here, called Niagara Shale. This was succeeded and buried by the Niagara limestone, these two strata making the Niagara group. Further westward, as at Lockport, this limestone formed as a veritable coral reef, and even here large corals are found imbedded in the finer mass.

With this Niagara limestone ends the visible hard-rock record of our history. But it is certain that some later records have been destroyed—that is, some higher strata have been removed. The sea bottom would hardly be elevated so quickly as not to permit some detrital deposits upon the limestone, and probably heavy beds of shale and even limestone once capped the Niagara in this locality, which has itself been deeply eroded. Our strata dip or incline slightly to the southward. As we pass south we find in successively higher horizons the shales of the Salina group, and the limestones of the Onondaga and the Corniferous, all of which may have extended northward so as to bury this locality. So we can never determine the geologic date when sedimentation ceased here. But there was a day, sometime during either the Upper Silurian or the

(6) Natural History of New York, Part IV, Survey of the Fourth Geological District, by James Hall, Albany, 1843.

Devonian ages, when by the slow uplift of the land northward this Silurian sea-border region was permanently elevated above the Devonian sea. Immediately rock formation ceased and rock destruction began. Since that day, and for an immense duration of time, the history of our region has been wholly one of degradation. This was by chemical decay and disintegration under atmospheric agencies, erosion by rain and streams, the loosened material being borne off to the sea to form the marine sediments, now uplifted as rocks of later ages, or still forming in the oceanic waters. How long could this have lasted? We can gain a faint idea of the immensity of the time by enumerating the formations which have accumulated since the Niagara period: the remainder of the Upper Silurian formation with about 3,000 feet of shale and limestone; the Devonian with 20,000 feet of shale and sandstone and limestone, and four well marked periods; the Carboniferous with its three periods and 20,000 feet of sediments; the Triassic with 15,000 feet of sediments; the Jurassic with 5,000 feet; the Cretaceous with 30,000 feet; the Tertiary with three periods and 20,000 feet; a total of over 100,000 feet of slowly forming marine sediments. Geologic time, that is, since the ocean existed, has been estimated by geologists from 20,000,000 to 200,000,000 years. Probably the time since the Niagara is about one-half of the whole. During all these ages the work of destruction was carried on over this region, and a great depth of rock was doubtless removed. The topography or surface configuration was unlike that of the present, and this northern part of the continent stood in the Tertiary at a higher altitude. The drainage must have been very different and much more vigorous. There may have been in later time a stream having partly the same hydrographic basin as the Genesee, but of its course and features nothing is definitely known. Lake Ontario was not then in existence. There were no lakes and no cataracts in all this region, as they belong to the adolescent phase of streams. The character of the surface material was unlike that of to-day, being a true soil of decomposition, not a sheet of transported matter or drift.

The characteristic land life of the several ages came into being, flourished, culminated and disappeared: Amphibians in the Devonian and Carboniferous; true reptiles in the Carboniferous and Reptilian; Mammals and Birds in the Reptilian and Tertiary. During the Tertiary the Mastodon and Mammoth roamed over this region, with other strange creatures. No good evidences of man are found.

The forests probably surpassed those of to-day in the size and luxuriance of individual plants, for the climate was sub-tropical.

At last there came a remarkable change. It was felt at first in a slow lowering of temperature. Then with a decided change of climate, due to the height of land and the southward creeping of the polar ice-cap, came a change in the fauna and flora. In course of time the arctic ice-sheet reached and buried this region and expanded to the southward. For many thousands of years accumulation of snow in the highlands north caused a slow movement of the continental glacier over this area. The depth of ice at its maximum may well have been as much as two thousand feet. ([7]) By its weight and motion the superficial decomposed rocks were pulverized and removed, and in some places the erosion ate deep into the solid strata. The old drainage channels were either obliterated or filled with debris ; a sheet of heterogenous drift was spread all over the uplands ; huge masses of unassorted rocks and clay were accumulated at numerous places, while ridges of partially assorted matter were piled up by the action of the sub-glacial rivers. The Pinnacle Hills are a deposit of the latter kind. ([8]) Some American glacialists believe that there were two or more glacial epochs, with one or more interglacial epochs, when the ice sheet retreated far to the north, and that during the interval drainage channels were established, and vegetation took possession of the surface, or peat accumulated in the swamps, to be destroyed or buried under the re-advance of the ice. During the latter part of the Ice age the prevailing motion here was from the northeast, and the country is strewn with a great variety of hard boulders brought from the St. Lawrence and Canadian regions and intermediate points.

The evidence of human occupation of this northern region during glacial times has probably been over-estimated, and is not established to the satisfaction of the geologists.

The lake basin of Ontario was produced during the Ice age, probably by enlarging a pre-existent Tertiary valley and river channel, with some movements of depression and elevation of adjacent areas. After the recession of the ice-sheet from this area the Ontario depression was flooded, due to subsidence of the land, and the barrier of the ice in its northward retreat, so that a larger

(7) The distance from Rochester southward to the glacial boundary is about 75 miles. An average gradient of the glacier surface of 30 feet per mile would give something over 2,000 feet. See Professor T. C. Chamberlin's maps of the glaciated area in Third Ann. Rep., U. S. Geolog. Survey.

(8) "Eskers near Rochester, N. Y." By Warren Upham, in this volume, pp. 181-200.

lake called Lake Iroquois, (9) covered portions of this region and left shore lines or beaches, of which the "Ridge Road" is the most conspicuous near Rochester. Areas below the level of that beach have their glacial drift in many places covered thinly with lacustrine silt. Irondequoit bay was probably filled with such lake deposit. The final retreat of the ice and the lowering of the lake left the atmospheric agencies free to produce the surface configuration and drainage which we now have. The lacustrine deposits and underlying glacial drift have been eroded, producing the sand hills and the peculiar topography about Irondequoit, while the Genesee has carved for itself through the drift and rock strata the ravine in which it now flows. Niagara canyon has a history similar to that of our Genesee, and estimates upon its rate of formation allow several thousand years. The conclusions from all sources as to the length of time since the Glacial period seem to indicate that it has been only some 6,000 to 10,000 years. (10)

As exposed land above the sea our locality is very old, and has witnessed the greatest physical changes of the continents, in land expansion and mountain-making, and the evolution of the higher forms of life.

The geologic history of this locality may be summarized as consisting of four great divisions; first, the time of continuous submergence beneath the sea and sedimentation, lasting from the Archean to perhaps the Devonian; second, the time of exposure above the sea and erosion, from the Devonian to the Glacial period; third, the relatively short time of glaciation; and fourth, the present brief period of the renewal of the conditions of subaërial erosion.

The paper was discussed by Dr. E. V. Stoddard, Professor A. L. Arey and others.

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(9) See articles: Warren Upham, *Bulletin of the Geological Society of America*, Vol. 2, pp. 260–264. G. K. Gilbert, "Changes of Level in the Great Lakes," *The Forum*, Vol. 5, June, 1888, "The History of the Niagara River," 6th Ann. Rep. Commissioners of the State Reservation at Niagara, for 1889, Albany, 1890. J. W. Spencer, "The Deformation of Iroquois Beach and Birth of Lake Ontario," *Amer. Jour. Sci.*, Vol. 40, 1890, pp. 443-451.

(10) For a succinct statement of the concurrence of geological evidence bearing upon this point, see *The Journal of Geology*, Vol. II, page 142, in article on "The Glacial Succession in Norway," by Andr. M. Hansen.

November 14, 1893.

STATED MEETING.

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

Thirty persons present.

The Council report recommended :

(1.) The payment of certain bills.

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

Mr. William C. Barry,
Mr. William E. Crane,
Mr. James B. Morman,
Mr. Edward D. T. Swift.

The report was adopted, the bills ordered paid, and the candidates were elected by formal ballot.

The Librarian, Miss Mary E. Macauley, made the following report which was read by the Secretary :

The Librarian would respectfully submit the following brief report : Since the adjournment of the Society in June, there have been received about three hundred pamphlets and fourteen bound volumes. As the exchange list of the Academy now includes the leading foreign societies, as well as those of America, we are in almost daily receipt of valuable additions covering the whole field of science, so that by the end of the year the library will probably number 2,500 volumes. We also receive regularly a number of valuable periodicals. Among these may be mentioned *The American Naturalist; Amer. Microscopical Journal; Botanical Gazette; Bulletin Amer. Geographical Society; School of Mines Quarterly; Canadian Entomologist; Technology Quarterly.* Mary E. Macauley,
Librarian.

The following memorial was read :

A MEMORIAL OF GEORGE H. HARRIS.

By Mr. J. G. D'Olier.

In the year 1816, there moved to Rochester from Otsego county, N. Y., a Mr. Daniel Harris. This gentleman purchased a farm which included what is now Mount Hope Cemetery, and built a log cabin in front of where Mr. Ellwanger's residence now stands. With other children he brought with him Daniel Ely Harris, a boy of three years. Young Daniel's boyhood was spent on the farm, sharing the hardships and pleasure of pioneer life.

In 1836, Daniel Harris married Miss Strickland, a relative of Agnes Strickland, authoress of "The Lives of the Queens of England" and a sister of General Silas A. Strickland. Of this marriage was born George Henry Harris, the subject of our sketch, in West Greece, Monroe county, on the 29th of December, 1843.

During George Harris's early years his father was a contractor, which probably accounts for the fact that while yet a lad he had lived in Charlotte, Rochester, Hinsdale and Buffalo. His grandfather was also interested in public works and almost ruined himself on a contract to deepen a section of the Erie canal, having to blast an immense quantity of rock not counted on. When George was a lad of twelve years his father moved with the family to Green Bay, Wisconsin, where he engaged in the lumbering business. As the boy was in delicate health the physician advised his father to take him out of school and let him run wild in the woods for a year. That year instilled in the boy a love of nature, canoe, camp and rifle that never waned while life lasted. It was always a pleasure to him to live over in memory those days, telling of the many adventures that he had with a young companion. Having regained his health he was apprenticed, at the age of fifteen, to a watchmaker. This man was a student of history, and without doubt it was largely due to his influence that the boy's taste turned to historical subjects. Three years later he came back to Rochester and entered Pierce's Military Academy, in a building that stands on the northeast corner of Spring and Fitzhugh streets. As in everything he undertook he soon mastered the details of military tactics, and in 1863 he joined Company K, 54th Regiment, in which he held the rank of orderly sergeant. When his regiment was disbanded he returned to Rochester, and his health again failing, he engaged in farming for a time, after which he went to Oil City, and in the spring of 1868 to Omaha. Here, after trying farming and store keeping, he was appointed on the night force of the post office. In this duty he came near ending his career in a bloody adventure with a burglar. Later he was appointed first mail clerk between Omaha and St. Joseph.

Trusting to a friend to get out papers for a claim which he had taken up near Omaha, and upon which he had spent all his spare cash, he found like many another that the friend had played him false and had taken out the papers in his own name. Returning to Rochester he studied surveying and landscape gardening under Mr. Stillson at Mount Hope.

In 1872 he married Miss Julia E. Hughes, and moved to Peterborough, Canada, where he laid out and beautified the Little Lake cemetery, which stands to-day a monument to his skill as a landscape gardener, being one of the most beautiful in the Dominion. Having finished his work in Peterborough he moved to Detroit, Mich., where he took charge of Elmwood cemetery, but once more his delicate health stood in his way and he was forced to give it up. He then returned to Rochester. This was about 1877.

And now commences that part of his life which is most interesting to us. Two years after coming back his family went away for a time, and to while away the lonesome hours after his day's work was done, he took up the study of history, reading everything he could get relating in any way to the early settlement of the Genesee Country, as well as all works bearing on the Seneca Indians. He also took long tramps following up the old Indian trails and locating their villages, looking up old settlers and gleaning from them all they could remember of pioneers and pioneer life. It was most interesting to listen to him catechise some old resident, awakening memories by some incident of long ago. Mr. Harris made friends wherever he went. His gentle nature coupled with a rare faculty of thinking about the little things of life endeared him to his friends and companions. A striking characteristic was his capacity for details.

All his life Mr. Harris was a frequent contributor to the newspapers, and on all sorts of subjects. For several years he was editor of the "Odd Fellows' Column" in the *Rochester Herald;* but his contributions to the history of the Genesee Country have given him a unique place among local historians and entitle him to more than a passing notice by this Society. His best known work, that has made his name familiar to all students of our early Indian History, is "The Aboriginal Occupation of the Lower Genesee Country." The value of this work cannot be too highly estimated, containing as it does facts gathered from old residents, with whom would have perished much that is of great interest, had it not been for the untiring labors of Mr. Harris.

In Mr. Harris's terminology of the Genesee Country he has left us a most valuable collection of Indian names. In tracing the Indian paths or trails that once crossed and re-crossed the Genesee Valley like a network, he had a field of labor distinctively his own and that he excelled in it is witnessed by the following letter from the Honorable George S. Conover :

To the Editor of the Morning Herald:

The Seneca Indians have long been aware of the great interest that George H. Harris of Rochester, N. Y., has manifested in resurrecting Indian history, and the energy he has exhibited in locating the sites of their former villages. On account of the remarkable success he has had in tracing out and locating the Indian paths or trails that once laced the Genesee Valley, they have recognized and called him the Pathfinder. A letter lately received from Chester C. Lay, the United States interpreter for the Senecas on the Cattaraugus reservation, says that in recognition of so eminent an Indianologist as Mr. Harris has become, it has been decided to show their appreciation by adopting him into the tribe and bestowing upon him the name of Ho-tar-shan-nyooh, meaning " he has found the path," or " The Pathfinder." As Mr. Lay is of the Wolf Clan, it necessarily follows that Mr. Harris among his Indian brethren will be recognized as a member of the Wolf Clan, the same clan to which Red Jacket belonged. This is a well merited tribute and worthily bestowed, as Mr. Harris has been for many years a diligent and pains-taking investigator of early local history, and has won for himself an enviable reputation, being an acknowledged authority on Indian antiquities of the region around Rochester and the Genesee Valley.

Geneva, N. Y., February, 1889. (Signed) HY-WE-SAUS.

In making researches Mr. Harris was struck by the prominent part played in the early history of Western New York by Horatio Jones, his name recurring again and again. He was a man of good family, whose early training, coupled with a fine physique and wonderful powers of endurance, eminently fitted him for the remarkable sequence of adventures through which he passed. Running away from home when a boy, to fight the Indians, he was captured, made to run the gauntlet and finally adopted by a Seneca family. Becoming master of the language and customs, he obtained the entire confidence and esteem of the Indians and figured prominently in many important treaties as interpreter. Indeed Mr. Harris found this man to be so woven into the early history of the country that he became impressed with the idea of making him the grand figure around which to group the many startling scenes of early times. This plan he carried out ; and in writing the life of Horatio Jones he has written the history of the Genesee Country, at the same time working in numerous incidents of Indian life, warfare, captivity, hunting and sport, that will make the book of thrilling interest. Before he laid down his pen forever he had brought his hero down to a point where everything of historical value had been recorded, and it only required a few closing scenes to have the work ready for publication. Mr. Harris left many other manuscripts which when compiled will undoubtedly be of much public interest.

The following letter is a touching tribute to his memory :

Hon. G. S. Conover,

My dear Friend :—I have just learned of the death of Geo. H. Harris, Esq., that eminent co-laborer in the field of Indian investigation, and I assure you my heart is sad at the unexpected intelligence. One by one the old familiar names and faces fade from view, and that band of faithful, earnest workers in the broad field of local research becomes smaller in numbers. Cut down in the prime of life, full of ripe experience, only fifty years of age, his loss is, indeed, irreparable. Often during my journeys in making personal investigation of the many historic localities connected with our early history, have I crossed the trails where he had visited, and I found but one opinion concerning him, the courteous gentleman, the ripe scholar, the faithful investigator. Often have I compared his conclusions with my own, after a careful survey, and have been compelled to acknowledge the rare fidelity of his work. In his wanderings he was beloved by all with whom he came in contact, the learned and the unlearned, the rich and the poor. He was an enthusiastic lover of Nature and many of his happiest hours were spent in traversing her forests and streams. A few weeks since I received a kindly note from him in acknowledgment of a trivial favor granted which I shall ever treasure, as it breathes the innate nobleness of the man ; full of the purest suggestions, and wishing me all success in my humble efforts to unveil the secrets of our early Indian history. God bless his memory ! My heart goes out in love and sympathy to his family in this their hour of deep affliction.

I am yours truly,

Shortsville, N. Y., Oct. 16, 1893. Irving W. Coates.

Mr. Harris was an honorary member of the Buffalo, Waterloo, and Livingston County Historical Societies, and an active member of the Rochester Academy of Science, the Rochester Historical Society, and the American Association for the Advancement of Science.

Writings of George H. Harris.

Western New York. Sketches, Incidents and Historical Events of the Early Inhabitants. *Rochester Sunday Morning Herald.* August 17th to December 21, 1879.

Site of an Ancient Town Discovered near Rochester. *Rochester Sunday Morning Herald.* December 7, 1879.

Mound Builders. *Rochester Sunday Morning Herald.* October 31st and November 7, 1880.

An Ancient Fort. *Rochester Sunday Morning Herald.* January 25, 1880.

Aboriginal Remains on the Genesee. *Rochester Sunday Morning Herald.* October 23, 1881.

A Canoe Cruise Down the Genesee. *Rochester Sunday Morning Herald.* October 29 to November 26, 1882.

Western New York. The First Newspaper. *Victor Herald.* August 10, 1882.

Was He a Mound Builder? *Rochester Post-Express.* March 12, 1882.

Aboriginal Occupation of the Lower Genesee Country—being the first fifteen chapters of *Peck's History of Rochester.* 1884.

Early History of Western New York. *Livingston County Herald* January 28, 1886. *Rochester Post-Express.* January 13, 1886.

Joseph Brant. *Rochester Post-Express.* October, 1886.

Invasion of '64. *Rochester Post-Express.* February 7, 1887.

De Nonville's Expedition. *Rochester Morning Herald.* July 27, 1887.

An Historic Elm. The Story of the Great Elm on the Markham Estate. *Rochester Democrat and Chronicle.* May 13, 1888.

Aboriginal Terminology of the Genesee River. *Proceedings Rochester Historical Society.* 1889.

Pioneers of the Genesee Valley, the Markhams. *Proceedings Rochester Historical Society.* 1889.

Aboriginal History of Irondequoit. *Rochester Union and Advertiser.* March 9, 1889.

Traces of the Red Man, Shall the Parks be Named in Their Honor? *Rochester Morning Herald.* March 26, 1889.

Letters from the Pathfinder. *Rochester Post-Express.* September 14–15, 1889.

Root Foods of the Seneca Indians. *Proceedings Rochester Academy of Science, Vol. 1, pp. 106–117.*

Indian Bread Root. *Waterloo Observer.* May, 1890.

Indian Implements Found in Irondequoit. *Rochester Post-Express.* June 9, 1891. (Note in *Proc. Roch. Acad. of Sci., Vol I, p. 181.*)

Guy Markham; a Talk with the aged Pioneer. *Rochester Post Express.* January 3, 1891.

Guy Markham; Ninety-first Anniversary Celebrated in a Log Cabin. *Rochester Post-Express.* September 18, 1891.

Pioneers of the Genesee Valley; Van Campen and Church. *Rochester Post-Express.* May 21, 1892.

The Removal to Mount Hope Cemetery, in 1841, of the Remains of Lieutenant Thomas Boyd and other Soldiers of General Sullivan's Army. *Journals of Gen. John Sullivan's Indian Expedition.*

Elihu H. Grover. Sketches of His Life, with Historical Reminiscences. *Rochester Post Express.* May 2, 18—.

Campaigns of Baron La Hontan. *Rochester Post-Express.* August 4, 1892.

Mr. S. A. Ellis, in behalf of the committee on memorial resolutions, read a report as follows:

To the Rochester Academy of Science:—

Your Committee appointed to prepare a memorial of the late George H. Harris, beg leave to submit the following, and would respectfully recommend that it be entered upon the minutes of the Academy and that an engrossed copy be sent to the family of the deceased :

In the death of Mr. Harris, the Academy has lost one of its most helpful and valued members. He was widely known as a diligent and successful student of Indian history, especially that of the Six Nations, and was very familiar with the history of the early settlers of the Genesee Country. He was the trusted friend of the leading Seneca Chiefs now living; was an adopted Seneca and received the name of Pathfinder, on account of the information he had given regarding the "trails" through this region. In all matters relating to the Indians of Northern New York,—their life, manners, customs, burial places, castles, etc., his knowledge was both accurate and complete. He was a most conscientious and painstaking investigator, never committing himself to any statement until he was sure of his facts. This quality gave to all his work a permanent value and made him a safe guide in the fields of research he explored. It is to be hoped that the many interesting and valuable papers he had read before various societies and scientific associations, together with a large amount of material yet unpublished, may eventually be put into permanent form. They contain much valuable information not obtainable elsewhere. His collection of Indian relics, books and manuscripts bearing upon the subjects of his investigations, is the largest and best in this section.

Mr. Harris was a very busy man, having the management of a large property that demanded his constant care and attention, and it is worthy of record that his historical studies and investigations were carried on in the intervals of business and on holidays, periods that most men make little account of.

He was a most genial friend and an agreeable companion, and those who had the privilege of a holiday stroll with him in search of a "lost trail," the site of an Indian village, old burial place or camp ground, will not soon forget the delightful occasion. His loss in the realm of local history is irreparable, as he leaves no successor.

The sympathy of the members of the Academy is extended to the bereaved and sorrowing family.

S. A. Ellis,
Adelbert Cronise,
Henry C. Brewster,
Committee.

The report was unanimously adopted as the sentiment of the Society, and ordered published.

Mr. Arthur L. White, U. S. Weather Observer, read a paper entitled :

THE EFFECT UPON CLIMATE OF DEFORESTATION AND AFFORESTATION.

In this paper Mr. White suggested that the decadence of ancient Asiatic civilization might be partly due to unfavorable climatic conditions produced by deforestation. He gave statistics of the amount of woodland in the United States and in New York ; the rate of timber destruction, and showed how at the present rate of cutting there would soon be a dangerous lack of forest. He discussed the causes of rainfall and the climatic effects of forests, and also considered their hygienic, economic and æsthetic value.

Remarks were made by Mr. Arthur S. Hamilton, President of the Forestry Association, and Mr. Herbert Wadsworth, of Avon, N. Y.

The President read a communication from the Smithsonian Institution in reference to the Hodgkins fund prizes for essays upon the properties of atmospheric air.

The President described briefly the results of the work of Mr. Frank Leverett in tracing glacial moraines through Western New York, and stated that the Pinnacle Hills esker was found to terminate at its western extremity near the Fireman's monument, Mount Hope Cemetery, in a low moraine passing through the southwestern and southern portion of the city in a direction approximately northwest and southeast.

December 11, 1893.

STATED MEETING.

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

A small number of persons present.

The following paper was read :

THE MECHANICAL PROBLEMS INVOLVED IN IMPROVED CANAL NAVIGATION.

By F. W. Warner.

(Abstract.)

It has been proved by actual experiment in this country as well as in Holland that it costs only about one-third as much to transport goods by canal as by rail. In railroad transportation, besides the coal and water used, the important factors of the wear and tear of ties, rails, plates, the rolling stock, the expensive lubricants, and necessary attention are all to be considered. In canal transportation these factors are all eliminated, and the weight of the freight and boat rests upon the water which is the best and cheapest lubricant in overcoming the friction of motion. In making the comparison of cost, however, it must be taken into consideration that the railroads have for the last forty years received the best thoughts of the most skillful inventors, and thousands of patents on new and useful appliances have been granted by the government, which have had for their object increasing the efficiency of the roads and decreasing the cost of transportation. It is different, however, in the matter of canal navigation, for transportation on the canals is hardly up to the standard of efficiency and economy which it had attained forty years ago.

The subject of the efficient and economical use of the water ways presents the most promising field for the skillful inventor. With the best mechanical and engineering skill given to canal navigation, we would find that the carrying capacity of the canal could be increased ten-fold and the cost of transportation could be reduced to a fraction of the present rate.

The problems which are involved in the subject of improved canal navigation are many and of a widely differing nature. In a brief paper it is only possible to outline some of them and offer suggestions as to their solution.

The problems of navigation naturally fall under the following heads : first, what motive power will prove most practicable of application, can be supplied at the lowest cost, and show the best results in speed ; second, in what manner can this power be best utilized in moving boats ; third, how can we best overcome the resistance offered by the water to the progress of the boats.

The first of these propositions has received the greatest attention but is in reality of the least importance. Electricity does precisely what is done by steam, and is more or less expensive according to the methods by which it is generated. It is certain that animal power which is now in almost universal use will soon be superseded by generated power; but exactly what that power will be is of little importance as compared with the other questions involved.

It is highly probable that electric energy generated by water power will be used on the ground of economy. There is sufficient water power, at the present time, running to waste between Buffalo and Albany to do the work of the Erie Canal for many times its present volume of business.

The question of the manner in which the power is to be applied opens up a wide and important field for study and experiment. The successful introduction of generated power upon the water ways will depend largely upon the manner in which the power is applied.

There are four methods presented by which the power may be applied: first, the power may be applied by the revolution of paddle wheels or propellers acting upon the water; second, the power may be applied in connection with a rail or cable suspended over the canal and above the boat; third, it may be applied in connection with rails or cables submerged and lying on or near the bottom of the canal; fourth, it may be applied to a motor or other device on the berm bank or on the tow path.

The propulsion of canal boats by steam power is in common use It is open to the objection of being injurious to the canal unless the entire prism of the canal is rubbled. The banks of an ordinary canal are washed down and weakened and the bottom is correspondingly filled. The power is largely wasted in agitating and pushing against the elusive and unstable water. Should the same power be exerted with a base or purchase upon *terra firma*, as, for instance, in pulling with a rope secured to a fixed object, a far greater speed would be made.

It is far easier to push a boat forward with a pole than to propel it with oars. Study and experiment on this line will inevitably lead one to the conclusion that the canal boat of the future will not be moved by a paddle or propellor, but will either have the motive power on land or upon the boat and acting upon a fixed object.

It is undoubtedly a practicable scheme to move a boat either by power, carried by the boat, acting upon a fixed rail suspended above the boat or by means of a moving overhead cable. There is no reason why a suspended moving cable drawing the boats might not be as practicable as a cable railroad. A suspended geared rail or sprocket chain, so suspended as to resist a longitudinal strain, and insulated so as to convey an electric current, with a trolley wheel geared so as to mesh into the trolley rail, would move a boat just as a street car is moved on the trolley system. Other practicable methods under this head have already been the subject of study and experiment. It is no less practicable to move the boats by means of submerged cables like the Belgian system which have already been operated on the Erie canal, or by submerged tracks, using either geared traction or beam track and partially submerged wheels. Several systems on this plan have been elaborated which would, if fairly demonstrated, possibly prove efficient and valuable.

By far the most simple and probably the most practicable method of applying generated power, is to apply it on the tow path, by traction ; that is, a motor drawing the boat. Three mules with their sharp shoes gripping the path will draw two loaded boats two and a half miles per hour ; while it will take an engine of from forty to fifty horse power, turning the propellor, to accomplish the same result. A motor of twenty horse power will draw a train of ten or more boats, if arranged under proper conditions, at a speed of from four to five miles per hour.

A traction motor would probably do best if operated by electricity. It should be low, narrow and heavy. Double tracks would admit of boats passing in both directions. A guard rail running lengthwise on the top of the motor, with the ends sweeping nearly to the ground, would act as an automatic device for picking up and passing the tow ropes. When navigation is suspended the tow path railroad could be used for transporting of freight and passengers.

The question of how to overcome the resistance of the water is probably the most interesting and important with which we have to deal. It is found in marine engineering that a steamer, we will say, of three hundred feet in length and thirty feet beam can be propelled almost as fast as a steamer but two hundred feet in length and the same beam, using the same power. For the same reason a single log fifty feet in length will tow much easier than five logs, each ten feet in length, connected by lines. The motive power is expended largely in displacing the water as the boat advances. Each boat in this way makes its own displacement. The motive power should be economized in making one displacement of the water for a train of eight or ten boats. The boats should be built with a convex bow and a concave stern so that when coupled together the train is flexible and can conform to the bends in the canal. The stern or rudder boat should be built so as to best answer the purpose of a rudder and be operated by ropes connected with the windlass on the bow boat. The places where the boats are connected should be covered with iron aprons so as to make an unbroken water line. These aprons could be worked by the man at the wheel so as to throw them out at right angles with the boats and act as a brake in checking the speed.

The greatest commercial need of the country at the present time is cheaper transportation between the great west and the seaboard. Capital is awaiting the development of a perfected system of canal navigation before constructing a great system of water ways from the Mississippi to the Atlantic. It only remains to combine the firm iron grip on *terra firma* of an improved motor with the heavy freights in boat trains, floating on the quiet waters of the canal, to reduce the freight rates to a mere fraction of the present cost. The problem of canal navigation can undoubtedly be solved on the lines above indicated.

The paper was discussed by Professor A. L. Arey, Mr. J. Y. McClintock, Mr. J. E. Putnam and others.

January 8, 1894.

FIFTEENTH ANNUAL MEETING.

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

On account of the small number of members present, due to the stormy weather, the business of the Annual Meeting was deferred to the next stated meeting of the Academy.

January 22, 1894.

DEFERRED FIFTEENTH ANNUAL MEETING.

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

A large number of persons present.

The Council report recommended the appropriation of money for Secretary's expenses. The report was adopted.

The Annual Reports of the officers were presented, as follows :

SECRETARY'S REPORT.

The report of the Secretary, PROFESSOR ARTHUR L. BAKER, is summarized as follows :

During the year fourteen meetings have been held, with an average attendance, not counting the popular lectures, of thirty three.

Eleven papers have been read, classified as follows:—Geology, two ; Astronomy, Bacteriology, Biography, Engineering, Geodesy, Mathematics, Mechanics, Meteorology, Zoölogy, one each.

Four popular lectures have been delivered, one each in Archeology, Ethnography, Geography, Paleobotany.

Twelve active members and one honorary member have been elected, and twelve members have been lost by death or resignation. The present membership is as follows :—honorary members, 10 ; corresponding members, 33 ; life members, 1 ; fellows, 37 ; active members, 118. Total membership, 199.

CORRESPONDING SECRETARY'S REPORT.

PROFESSOR CHARLES WRIGHT DODGE, the Corresponding Secretary, presented a report as follows :

As heretofore the work of this office has consisted mainly in distributing the publications of the Academy and receiving those of other societies sent in return. Of Brochure 2, Volume II, there have been distributed three hundred ten (310) copies to foreign societies, one hundred eighty (180) to societies in the United States and Canada, and thirty-three (33) to corresponding, eight (8) to honorary and one hundred fifty-one (151) to active members. The total number distributed is six hundred eighty-two (682), an increase of fifty-one (51) over the number of the last brochure. This increase is due entirely to the fact that many prominent societies, mainly foreign, have sent their publications with the request that ours be sent in exchange. Thus, the Academy with very little cost to itself is gradually acquiring an extensive and valuable library consisting mainly of the papers published by the original investigators belonging to the various scientific societies of the world.

Respectfully,

CHARLES WRIGHT DODGE,

Corresponding Secretary.

TREASURER'S REPORT.

The Treasurer, MR. J. EUGENE WHITNEY, made a report of the finances of the year, of which the following is a summary :

Balance on hand, January, 1893,	$334 81
Receipts during the year,	466 00
Total,	$800 81
Disbursements during the year, as per vouchers.	638 68
Balance,	$162 13

LIBRARIAN'S REPORT.

The report of the Librarian, MISS MARY E. MACAULEY, was not read at this meeting, but is here summarized as follows :

Number of bound volumes received during 1893, 32 ; number of unbound volumes and pamphlets, 953 ; total accession for the year, 985.

Number of bound volumes in the library, 125 ; number of unbound volumes and pamphlets, 2,464. Total, 2,588.

BOTANICAL CURATOR'S REPORT.

The Curator in Botany, MR. J. B. FULLER, stated that during the year there had been added to the herbarium about 300 specimens, collected by members of the Botanical Section. The total number of mounted and labeled specimens is now 3,210.

REPORT OF BOTANICAL SECTION.

Read by MRS. J. H. MCGUIRE, Recorder of the Section.

The Section has held its meetings with regularity every two weeks during the whole year, and has met, as has long been the custom, at the residence of Mr. William Streeter. To Mr. Streeter the Section and the Society are under great obligation for his hospitality and his devotion of time and material to the botanical work.

The officers of the Section are : President, MISS MARY E. MACAULEY ; Vice-President, MISS FLORENCE BECKWITH ; Recorder, MRS. J. H. MCGUIRE.

Extracts from the Minutes of the Section.

January 13, 1893. Dr. Anna H. Searing exhibited specimens collected last Spring on her trip through Mexico, California, Colorado and Kansas. These specimens numbered about 175 and were mounted and labeled. Among the genera most largely represented were: *Gilia*, *Astragalus*, *Lupinus*, *Trifolium* and *Allium*.

A specimen from Roane Mountain, Tenn., referred to Dr. Searing for identification, was found to be *Leiophyllum buxifolium*, var. *prostratum*.

Miss Beckwith exhibited a number of specimens, mostly from the White Mountains, from Dr. Bradley's herbarium, lately presented to the Academy.

January 27, 1893. Miss Beckwith exhibited diatomaceous earth found near Los Angeles, Cal., in 1892, and sent to the Academy of Science by the San Francisco Microscopical Society. Mr. A. M. Dumond showed a cultivated water-plant, *Eichornia Crassipes*, *major*, having a vigorous growth.

Mr. Dumond exhibited *Scendesmus quadri-caudatus*, and *Lemna trisulca*, and reported having found *Spirogyra* in conjugation after October 20th.

February 10, 1893. Dr. Searing exhibited representative specimens of pressed ferns, arranged to show the variations in growth in different localities. There were 106 specimens of 27 genera, found in Binghamton, N. Y., Pennsylvania, Vermont, Florida, Colorado, California, Bermudas, Bahamas, Mexico, Brazil, Ecuador, England, Ireland, Switzerland, Capri, Italy, Mesopotamia, New Zealand and the Sandwich Islands.

Mr. John Dunbar exhibited a number of cultivated shrubs.

February 23, 1893. Mr. C. C. Laney exhibited buds of *Alnus serrulata*, a small branch of Georgia Pine with cones, and a number of pressed plants from California.

Miss Beckwith exhibited a series of Ferns belonging to Mr. Seeley's collection, and loaned by him to the Section. The specimens were some which had been received from P. Neill Fraser, a noted fern collector and cultivator of Edinburgh, Scotland, being fronds taken from plants raised from spores by E. J. Lowe, the author of "Ferns, British and Foreign." These fronds, representing about 65 varieties, were all from *Asplenium filix-fœmina*, and showed great diversities of forms. Some of these were but slight changes from the typical form, by the forking of a few of the terminal pinnæ, others would have still more of the pinnæ forked until the whole frond including every pinnule was involved in change. In some cases the outline of the fronds was almost linear, caused by contraction and curling. It is impossible adequately to describe the changes of form presented by these specimens by the incision, forking, tasselation and curling of the pinnules and pinnæ and manifold variations of all parts of the fronds. The susceptibility of this species of *Asplenium* to modifications of its form under the influences of cultivation, as displayed in this set of specimens, has enabled fern cultivators to originate almost innumerable varieties from which have been selected those most pleasing and desirable, and these are propagated by division, perpetuating their peculiarities. They are raised as pot and basket plants for their ornamental qualities. More than a hundred varieties of this species are named and described in trade catalogues. One of the most beautiful varieties was named "Victoria, Queen of Lady-ferns."

Microscopical Studies.—Mr. Streeter exhibited filterings of Hemlock water in which were found *Cyclotella aperculata*, *Fragellaria capucina*, *Asterionella formosa*, *Botrycoccus Braunii*, *Gleocystus vesiculosa*, besides Infusoria and Rhizopods.

Miss Beckwith showed a flower stalk of a cultivated hybrid French Canna, "Madame Crozy." The falling of the pollen before the opening of the bud is said to be a peculiarity of this plant.

Mr. Laney reported finding *Ailanthus* growing wild on the river bank at Seneca Park.

Mr. W. W. Parce stated that he had observed in budding the Grape Fruit on the Orange, that the roots supporting the side bearing the former were larger and lighter in color than those supporting the latter, from which he would infer that each twig had its own specific root.

Microscopical Studies.—The examination of Hemlock water was continued by Mr. Streeter who showed *Staurastrium monticulosum*, *Cœlospharium Kutzingianum*, *Cosmarium depressum*, *Chlamydococcus pluvialis*, and others.

March 22, 1893. Microscopical Studies.—Among the objects examined were : *Scendesmus quadri caudatus*, *Protococcus*, *Pandorina*, *Navicula peregrina*, *N. digitus*, *Nitzschia panduriformis*, *N. coarctata*, and *Pleurosigma Spenceri*.

May 5, 1893. Miss Beckwith showed *Peziza coccinea*, and specimens of *Hepatica* having round sepals and twice the usual number.

They will be planted in Highland Park that further developments may be noted.

May 12, 1893. Twenty-six species were collected in woods west of Sea Breeze at this date. Among them were: *Coptis trifolia*, *Aralia trifolia*, *Chrysosplenium Americanum*, *Viola sagittata*, and *Saxifraga Pennsylvanica* in bud.

May 19, 1893. Miss Beckwith exhibited *Corydalis flavula* from Lime Rock, reported for the first time from this vicinity.

June 5, 1893. Professor W. H. Lennon, who had just returned from Bergen, reported having found there *Mitella nuda*, *Listera cordata*, *Cypripedium candidum*, *Ranunculus multifidus*, and a number of Carices. He also reported finding *Stellaria graminea* and *Alyssum calycinum* in Holley.

Miss Beckwith exhibited some specimens of *Climacium Americanum* in fruit, and reported having found a new station at Riga swamp for *Orchis spectabile*, *Cypripedium spectabile*, *Mitella nuda*, *Streptopus roseus*, *Acer spicatum*, *Linnæa borealis*, and *Drosera rotundifolia*.

Mr. Dunbar exhibited *Polygala Senega*, *Waldsteinia fragarioides*, *Staphylea trifolia* and other plants.

June 19, 1893. Miss Macauley gave a report of the excursion to Bergen swamp on the 17th instant and exhibited specimens of flowers obtained, among which were: *Smilacina stellata*, *Polygala paucifolia*, and *Arethusa bulbosa*. *Cypripedium spectabile* was not yet in blossom, but *candidum*, *parviflorum*, and *pubescens* were abundant, as were also *Linnæa borealis* and *Sarracenia purpurea*. There were also found eight species of Ferns, three Mosses and eleven Carices.

Mr. A. M. Baxter exhibited *Spiranthes latifolia*, and *Liparis Lœselii*, both rare in this vicinity; the latter was found at Adams Basin.

Mr. John Walton exhibited *Conopholis Americana*.

Miss Beckwith showed specimens of *Aphyllon uniflora*, found in Brighton.

July 3, 1893. Dr. Searing exhibited *Mertensia Virginica* and *Rhododendron maximum* found in Penfield, and pressed specimens of *Pogonia*.

Mr. John Walton exhibited a large number of original drawings in life colors, to be printed in his forthcoming work, "Our Native Flora."

Mr. Dunbar showed a fine collection of cultivated plants.

July 17, 1893. Mr. Baxter exhibited *Calopogon pulchellus*, *Pogonia* *ophioglossoides*, *Nymphæa odorata*, *Rosa setigera*, and *R. Caroliniana* from Mendon ponds.

Miss Beckwith reported finding *Rudbeckia hirta* with variations in color at the base of the petals, the same as she had found for two years previous in Gates. The markings and band of brown were very distinct. As this is the third year they have been found, they seem to have become established in that particular locality. (See former article in this volume, pp. 170–171.)

July 31, 1893. *Habenaria tridentata*, *Asplenium Filix-fœmina*, *A. thelypteroides*, *Solidago juncea*, *Hypericum Kalmianum*, were shown by Mr. Baxter and others.

August 14, 1893. Mr. Baxter exhibited a number of plants from Mendon Ponds, among which were: *Utricularia cornuta*, *Lycopodium clavatum*, *L. obscurum var. dendroideum*, *L. lucidulum*, *Nemopanthes fascicularis*, *Eriophorum Virginicum* (rare), *Scleria verticillata* (rare), *Dulichium spathaceum*, and *Scheuchzeria palustris.*

August 28, 1893. Mr. Baxter exhibited *Lechea major*, *Spiranthes gracilis*, *Drosera intermedia*, from Mendon, *Camptosorus rhizophyllus*, from Ogden, *Ophioglossum vulgatum*, *Chenopodium Botrys*, *Pogonia pendula* (rare), in fruit, and *Bartonia tenella* (rare), having both flower and fruit, from Adams Basin.

September 11, 1893. Mr. Baxter showed *Viola rotundifolia*, *Dicksonia pilosiuscula* and *Aspidium acrostichoides*, the latter having the pinnules divided and subdivided.

Dr. Searing gave a brief account of the meetings of the A. A. A. S. at Madison, Wis., and exhibited a number of the following pressed specimens from that vicinity: *Liatris squarrosa*, *Polygonum cilinode*, *P. Virginianum*, *Polygala sanguinea*, *Monotropa Hypopitys*, *Sullivantia Ohionis*, *Lycopus rubellus*, *Gerardia grandiflora*, *Solidago ulmifolia*, *Physostegia Virginiana*, *Corallorhiza odontorhiza.*

September 25, 1893. Miss Beckwith showed several specimens of *Monotropa uniflora* which had a decided pink color.

Mr. Baxter exhibited specimens of *Amphicarpæa monoica*, showing the underground blossoms.

Dr. Searing read a list of thirty-nine Fungi gathered by herself and Miss Beckwith the preceding week, as follows:—

1. *Amanita phalloides*, Fr.
2. " *rubescens*, Pers.
3. " *volvatus*, Peck.
4. " *strobiloformis*, Vitt.
5. *Lepiota oblitus*, Peck.
6. *Lepiota granulosus*, Batch.
7. " *acutesquamosus*, Wein.
8. *Clitocybe nebularis*, Batsch.
9. " *truncicola*, Peck.
10. " *carnosior*, Peck.

11. *Clitocybe candicans*, Pers.
12. *Collybia radicata*, Relh.
13. *Omphalia campanella*, Batsch.
14. " *umbellifera*, L. Pk.
15. *Hygrophorus conicus*, Fr.
16. " *ceraceus*, Fr.
17. *Russula lepida*, Fr.—Mild.
18. " *incarnata*, Mild.
19. *Marasmius campanulatus*, Peck.
20. *Pluteus cervinus*, Schæff.
21. *Pluteus longistriatus*, Peck.
22. " *admirabilis*, Peck.
23. *Inocybe violaceifolia*, Peck.
24. *Naucoria autumnalis*, Peck.
25. *Cortinarius autumnalis*, Peck.
26. *Cortinarius alboviolaceus*, Pers.
27. *Hebeloma rimosus*, Bull.
28. " *flocculosus*, Berk.
29. " *subochraceus*, Peck.
30. *Galera tener*, Schæff.
31. *Hypholoma perplexus*, Peck.
32. *Boletus sublutens*, Peck.
32. " *subaureus*, Peck.
34. *Polyporus lucidus*, Fr.
35. *Craterellus cornucopioides*, Fr.
36. *Clavaria fragilis*, Holmsk.
37. " *Kunzei*, Fr.
38. " *flava*.
39. " *cinerea*, Bull.

October 6, 1893. Mr. Baxter showed *Magnolia acuminata* in fruit, and also the fruit of *Asimina triloba*.

Mr. Laney showed *Hamamelis* in blossom.

Miss Beckwith exhibited a specimen of fungus donated to the Section by the President of the Academy. This fungus was said to have been found growing upon a timber in a coal mine at Scranton, Pa. It is about twenty-two inches long, consisting of a linear, slightly curved series of bulbous masses, the initial one having a diameter of two and one-half inches, and the series, sixteen in number, growing smaller to the terminal one with a diameter of one and one-fourth inches. At the top are two small, irregular, lateral bulbs or excrescences. It was suggested that the form might have been an interrupted attempt at maturing. The fungus has a hard, smooth rind, with no trace of pores.

October 20, 1893. Mr. Dunbar exhibited the fruit of twelve species of Roses showing a surprising variety in the shape and appearance of the fruit.

Dr. Searing exhibited specimens of *Salvinia natans* from Ohio. It is stated in Gray's Botany that this plant is found in Western New York but it has never been reported in this vicinity.

Mr. J. B. Fuller and Mr. Laney showed a fine collection of acorns comprising fruit from the White Oak, Bur Oak, Swamp White Oak, Chestnut Oak (*Q. Muhlenbergii*), Red, Scarlet and Black Oaks, and from an English Oak (*Q. pedunculata*).

Miss Beckwith showed pressed specimens of *Myrica cerifera* in fruit.

November 3, 1893. Miss Beckwith showed specimens of fungi which were pronounced by Dr. Searing to be *Cyathus striatus*.

Dr. Searing reported three species of fungi new to the locality.

November 17, 1893. Mr. Dunbar exhibited a number of Japanese shrubs and plants.

Mr. Baxter showed *Crepis tectorum.*

December 1, 1893. Mr. Fuller reported on a plant brought to the last meeting by Mr. Dunbar, and referred to him. He found it to be *Solanum rostratum*, introduced from the Southwest. The last edition of Gray's Manual includes it, and says it has become established as far as Tennessee. Mr. Fuller formerly found it abundant near Lyell Avenue, but had not seen it in twelve years.

Mr. Baxter exhibited fruited specimens of *Asplenium ebeneum*, obtained down the river November 30th.

Miss Beckwith showed pressed flowers from the Rocky Mts.

Mr. Stone mentioned finding *Myrica Gale* as a common shrub near Charlotte along the river. *Myrica cerifera* was also reported growing at Seneca Park, a single specimen.

December 15, 1893. Miss Macauley exhibited a book of California flowers artistically mounted and labeled. Also a large number of pressed plants from Connecticut.

Miss Beckwith showed a branch of Coffee plant with berries from Brazil, and a box of Paraguay Tea.

December 29, 1893. Mr. Dunbar exhibited fifteen species and varieties of *Rhus*, eight of which were from native trees and seven from foreign. The comparative properties of the different species were discussed.

Miss Beckwith showed *Peziza coccinea* gathered that day. Last Spring a decaying branch bearing a number of *Peziza* was brought from the woods, placed on the ground and partially covered ; from it had sprung this specimen with several others.

Mr. Baxter showed two specimens of dandelion picked in full blossom on Christmas.

ELECTION OF OFFICERS.

The annual election of officers for the ensuing year was held, and resulted as follows :

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, F. W. Warner.
Librarian, Miss Florence Beckwith.
Councillors,

For three years, { Miss Mary E Macauley. / J. E. Roseboom.
For two years, (to fill vacancy), { J. Y. McClintock. / J. Eugene Whitney.

A communication was read from Mr. E. H. Eaton, of Canandaigua, requesting licenses for himself and Mr. A. P. Wilbur to collect ornithological material. It was voted that the Academy grant such certificate, and the carrying into effect of the matter was left in the hands of the officers.

Professor Charles Wright Dodge presented a paper illustrated by lantern views, entitled :

THE STRUCTURE AND HABITS OF SOME WATER ORGANISMS.

The lecture was a popular account of the structure, mode of life, habits, reproduction, diseases, etc., of certain animals and plants sometimes found in water coming from Hemlock Lake. The object of the lecture was to interest members of the Academy in the study of these and of related organisms, all of which may be found at various times in water coming from faucets for domestic supply. Among the organisms described were: *Paramecium*, *Amœba*, *Vorticella*, *Actinophrys*, *Protococcus*, *Spirogyra*, *Œdogonium*, etc.

The lecture was illustrated by numerous lantern slides.

February 26, 1894.

STATED MEETING.

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

A small number of persons present.

Upon the suggestion of the President it was voted that certain Fellows of the Society be appointed to report, from time to time, matters of interest in the progress of their respective sciences. In pursuance of the above action, the President appointed as follows :

In Biology, C. W. Dodge ; Botany, Florence Beckwith ; Chemistry, J. M. Davison ; Electricity, J. E. Putnam ; Engineering, J. Y. McClintock ; Geology, H. L. Fairchild ; Hygiene, E. V. Stoddard ; Mathematics, A. L. Baker ; Medicine, M. L. Mallory ; Meteorology, M. A. Veeder ; Physics, A. L. Arey ; Physiology, J. L. Roseboom ; Zoölogy, Henry A. Ward.

The following paper was read :

SOLAR ELECTRICAL ENERGY NOT TRANSMITTED BY RADIATION.

BY M. A. VEEDER.

Radiation consists essentially of the divergence from common points of origin of minute wave motions traversing the ether of space. The medium in which these motions occur is beyond the reach of direct observation by any of our senses, and its motions are known to us only by the effects which they produce upon material substances. Light rays are themselves unseen although they make surrounding objects visible. Heat radiations which produce warmth as they fall upon the surface of the earth have no such effect upon the void of interplanetary space. Chemical rays are inoperative save only as they fall upon materials sensitive to their impulse. The thing that is conveyed in all these cases is simply a mode of motion of the ether. It is not light or heat or chemical force that is transferred through space but a system of pulsations which are capable of originating by direct contact the phenomena of color, visibility, heat or chemical changes, as the case may be, in bodies having the requisite physical properties. Even vital action may be caused by the impulse of such radiations, as is seen in the growth of plants exposed to light and heat, but it does not follow that vitality is a property of the ether.

The same distinction obtains in connection with such electrical effects as attend the impact of ether waves upon particular substances. Electricity is not a property of the ether in this sense at all, and there is no conveyance of electrical force whatever, but only of wave motions which are capable of having electrical effects under certain conditions, the same as all other forms of motion are capable of disturbing pre-existing electrical equilibrium even while incapable of the origination or conveyance of electrical force. Thus the faintest whisper falling upon the receiver of a telephone starts currents which are plainly perceptible. The atmospheric sound waves in such a case are not themselves electrical but in virtue of their motion, simply, produce electrical effects in the telephone. In the absence of such an apparatus they remain sound waves only, and do not have any such effects as appear in the case supposed. The energy that produces the currents resides not in the pulsations of the air, which have no power whatever in and by themselves to traverse the conducting wire, but in the molecular stresses and balancings existing in the materials of which the telephone is composed, which depend upon the possession by the apparatus itself of the requisite physical properties which in this case are of an electrical nature.

So when ether waves fall upon particular substances it is molecular or atomic motion only that is imparted. The effect produced whether chemical, electrical, or vital depends entirely upon the constitution of the substance receiving the impulse. It is the nature of the properties of the species of matter of which it is composed and not of those of the ether of space which determines what will be the result of the molecular motions imparted. This brings us to the consideration of the question as to what is meant by a property of matter.

The geometrical conception of matter and force which deals only with external forms and space relations is wholly inadequate. Matter thus conceived of is inert, and logically some form of inertia is its only property. Those who hold this view are obliged to assume that there is no lost motion but simply transformation of motion throughout the universe producing constant atomic agitation and ether pulsation. Accordingly there can be no motion without pre-existing motion and so on *ad infinitum*. It would seem very difficult, however, to analyze such a property of matter as elasticity into component motions in accordance with any principle of inertia which requires that the motion should be in straight lines. Nor will the assumption of the existence of complicated vortical motions whose origination is unexplained help the case. Atomic motions of any sort that can be conceived of would be subject to deformation by elastic strain as much as the shape of the body itself, and it becomes necessary to assume that there is some force or property inherent in the atoms that causes them to seek readjustment to a particular form whether they be in motion or at rest among themselves. This force whatever it may be although it maintains a certain form of arrangement among the atoms cannot be conceived of as having dimensions and shape. It is one of the properties of matter that does not come under the category of space relations.

So when a body falls to the ground and thenceforth remains stationary in that location it is not conceivable that it is held in place by any form of ether pulsation or atomic movement. It simply has weight, which is a property as essential to the existence of matter as is occupancy of space, but which cannot be represented under the same forms of statement. It is a force and is not to be pictured out as visibly extended and having parts and dimensions. In other words it does not come under the category of space relations. So likewise the thing that puts power into a gunpowder explosion cannot be defined otherwise than as being chemical force. In like manner the thing that puts life into a tree is vital force. These and all the other properties that might be named, such as cohesiveness, capillary attraction and the like, are essential to the very existence of matter in the forms in which we find it. Iron would not be iron if its chemical properties were lacking. A rose would not be a rose without the power of life and growth. So color, temperature, and electrical conditions are essential to various forms of existence as they actually appear.

On the other hand the manifestations of energy resultant from these properties cannot be had in the absence of the particular substances in which they reside. Even if the ether of space should have any of these properties they are not those of matter in the ordinary forms with which we are familiar. Thus if the ether has any electrical conductivity whatever, which is doubtful, it certainly is almost infinitely small as compared with that of iron wire and various other material substances.

Without entering further into the discussion of their general relations we proceed to the consideration of the behavior of magnetic storms specifically. Such storms may be expected to afford a test case as to the manner of conveyance of electrical energy through interplanetary space, they plainly being of extra-terrestrial origin. Here, if anywhere, evidence of transmission of electrical forces through radiation should appear. As a matter of fact such magnetic disturbances are apt to begin abruptly, it may be throughout the entire earth at practically the same instant of time. Thus in the case of very powerful outbreaks, within a few seconds at most, the magnets in all observatories begin to give evidence of agitation which is of such fitful and variable character that it cannot bear any relation whatever to preliminary heating or cooling, which would necessarily be slow and confined to parts of the earth exposed directly to heat radiations. In other words the evidence is conclusive that magnetic perturbations are not of thermo-electric origin and have nothing whatever to do with heat radiations. In like manner there is no relation whatever to light radiations. The photographic tracings which register automatically the movements of the magnets give a complete record of the times of occurrence of such storms, from which it appears that they must depend upon conditions entirely unlike those concerned in the radiation of light and heat. The maximum effect of magnetic storms is not recorded upon the side of the earth exposed to the direct rays of the sun but upon that opposite. So, too, the auroras accompanying magnetic storms, as seen in the Arctic regions at times when daylight does not interfere with their observation throughout the entire twenty-four hours, appear on the side of the earth away from the sun. Thus there is no diffusion of effect such as appears in the case of radiation. On the contrary there is concentration of the maximum phases of any particular outbreak at a definite hour angle from the sun and at certain latitudes which have reference to the magnetic poles of the earth. Furthermore there are recurrences of magnetic storms at the precise interval of a rotation of the sun as viewed from the earth, which is advancing in its orbit in the same direction that the sun is revolving on its axis. At each return at this interval magnetic storms and auroras as a rule begin suddenly and strongly and die out gradually, ceasing entirely most commonly within two or three days. From this it appears that whatever it is upon the sun that exercises these terrestrial magnetic effects has this power only when in a certain very definite location relative to the position of the earth. If outbreaks located promiscuously on every part of even the visible surface of the sun were able to have these effects, periodicity at the interval of a synodic rotation or any other regular interval would be impossible. Thus the impulse that produces a magnetic storm instead of being diffused indifferently in every direction from its point of origin, as are light rays, is confined to one direction exclusively. In short there is no analogy whatever between the behavior of magnetic storms and the origin and diffusion of heat and light radiations.

Our conception of radiant energy as exhibited in the case of heat and light has arisen from the analogy of atmospheric sound waves in which the ultimate particles composing the conducting medium are supposed to be thrown into a state of rythmical vibration. There is a bounding and rebounding of elastic particles against each other extending indefinitely in every direction from the point of origin of the sound. The resultant motions are in straight lines radiating from that point so long as the conducting medium remains homogeneous, the law of inertia not permitting any deviation from such direction in the case of bodies moving under its control exclusively. If however the continuity of the conducting medium be interrupted, secondary phenomena such as reflection, refraction or absorption may occur at the point of interruption. In order to the conveyance of heat and light in a manner altogether similar to that of sound it is only necessary to presuppose the existence of a medium more subtle and elastic than air, such as the ether is supposed to be. In this way the chief peculiarities in the behavior of heat and light radiations may be satisfactorily accounted for, but not the peculiarities which attend the conveyance from sun to earth of the impulses which originate magnetic storms.

It is true that light rays may have electrical effects, as for example when they come in contact with selenium. This signifies nothing more than that ether pulsations may produce a certain amount of superficial atomic readjustment such as appears in photography. If on the other hand chemical or electrical action in their turn originate light rays, these have no power to transmit the very force on which their origin depends. Were it otherwise, an electric light would be a deadly thing. If the power of the current traversing the carbons were conveyed by radiation to surrounding objects, it would cause serious inconvenience if not death to any individual so unfortunate as to be exposed to its rays. As a matter of fact, however, there is no reception or dispersion of electric force by radiation, certain small vibratory motions of the ether only being conveyed by this means which produce certain electrical effects mechanically, which are wholly insignificant as compared with the force of the dynamo traversing the conducting wire.

Such electrical effects as attend light rays persist uniformly and continuously so long as exposure to the source from which they emanate continues. Thus selenium has increased electrical conductivity in sun light which disappears in a darkened room just as photography ceases in like manner. Magnetic storms on the other hand are strongest on the darkened side of the earth, and instead of proceeding evenly and uniformly are characterized by large and fitful variations from hour to hour and moment to moment. In short there is no correspondence whatever between the behavior of such storms and the manner in which radiations of heat and light are originated and propagated from sun to earth.

Recently it has been discovered by Hertz that there are ether waves which do not produce light or heat or any other manifestation of radiant energy but still are capable of having electrical effects. These electric waves can be reflected the same as light waves and exhibit the remarkable peculiarity of passing through substances such as wood, which are impervious to light. Still they are wave motions only and are subject to the limitations which have been indicated throughout the course of the discussion. Their behavior resembles that of sound waves so closely that the term electrical resonance has been employed to designate their modes of action, which involve interference phenomena similar to those attended by increase or diminution of effect in acoustics. They are simply waves of a particular length and consequently have their own characteristic effects just as others of different lengths have chemical, or heating, or luminous effects chiefly. Mere differences of wave length does not alter the principles of radiation.

Nor will it help matters to conceive of vortices or rotary movements of the ether having complicated systems of interferences. It is possible that something of the sort may exist in magnetic fields that are sufficiently strong but the effects thus produced in immediate proximity to the poles of a magnet have nothing whatever to do with radiation in the ordinary sense of that term. Thus the rotary magnetic field ot Tesla and phenomena of kindred character do not enter into the question under discussion.

Not only is proof lacking that electrical energy is transferred by radiation from one locality to another, but there is positive proof on the other hand that it is thus conveyed with the utmost facility by the process known as conduction. Such conveyance by the agency of material substances having the requisite physical properties is consistent with the view that electricity is essentially a property of matter and not of the ether of space which was discussed at the outset. Electrical action of every species is to be classed with such properties of atoms as cohesiveness, chemical affinity, weight and the like, all of which are concerned in procuring definite forms of aggregation of matter. Thus in the case of particles free to move there are electro-magnetic systems of arrangement which have been fully identified and whose prominent characteristics are well known.

In the case of particles not free to move there are stresses and urgings which tend to bring about this same form of arrangement. It is in virtue of the possession of such properties that a magnet lifts its armature and holds it in position and not because of any bombardment of ether pulsations. This power of attraction, like that of gravitation, resides in the atoms themselves and does not depend upon anything external to them. Unlike gravitation, however, electrical attraction or repulsion does not even seem to act at a distance, its conveyance requiring a proper medium, thus involving perfect continuity in a series of material atoms in touch with each other. In the absence of a proper conducting medium, whether embodied in a wire or in the dust-like contents of interplanetary space, there can be no conveyance of electrical energy a single inch, to say nothing of any such distance as from sun to earth.

From this point of view all that we know about electricity is that it is a property of atoms which after the analogy of chemical affinity causes them to combine pole to pole in such manner as to satisfy what may be termed their electrical valency or power of entering into definite forms of adjustment in respect to each other. As well might we deny the existence of the attraction of gravitation, which does not appear to have any conceivable relation to ether waves, as to refuse to admit the existence of other forms of attractive force which may likewise be independent of ether waves and atomic oscillations of every sort. If only electrical currents were concerned it would be a question of motions, perhaps. The final outcome of electrical action is, however, an adjustment of stresses in particular directions having reference to poles and lines of force, so as to produce a state of equilibrium and consequent cessation of motion. Just as the armature of a magnet ceases to move and is held stationary when it reaches its proper position in contact with the poles, so too the atoms of which it is composed doubtless reach a definite adjustment and consequent quiet under the influence of electrical strain. The case is precisely similar to that in which a body falls to the earth and remains motionless thereon. If a body in this condition can be conceived of as being compelled to cling to the earth by the impulse of ether motions, a similar explanation might become possible in connection with the modes of operation of electrical forces above indicated. To the writer such a view appears to involve far greater difficulties than those sought to be explained. There is the question as to what must be the character of the motions of the ether that could accomplish such results, and the further question as to the manner in which these motions are sustained. With our present knowledge it seems preferable to assume as the starting point the existence of properties inherent in the atoms and independent of motion of any sort. To do otherwise than this is to resolve not only the properties of matter but matter itself into a question of wave length, the very existence of matter being unthinkable apart from that of its properties. In all reasonings something must be taken for granted as ultimate. In this case it is the existence of matter and of its properties, among which are those that characterize electrical action.

If the ether have electrical properties, the evidence is clear that they differ from those of matter which fit it to become a conducting medium. It is possible that light waves may excite some species of electrical action in the ether of space just as they do when falling upon material atoms. So on the other hand electrical action brought to bear upon any part of the ether of space may modify the light waves in that location. It is true that light has electro-magnetic relations which are a proper subject of investigation. The modification of light waves consisting in what has been termed their electro-magnetic rotation, which may perhaps depend upon certain electrical properties of the ether, does not transform them into anything else than light waves. They do not transmit anything except vibratory motions which may have electrical effects upon the ether of space and material atoms, but which do not transfer electrical energy from one locality to another. Ether pulsations produce only very strictly localized and small disturbances of electrical equilibrium in the atoms exposed to their direct impulses. In order so to do they do not deplete any source of supply, nor originate any bipolar system of arrangement of force, or in other words do not become a conducting medium in any sense of that term. Their mode of action is that of electrical excitation and not of conduction. The energy developed by a dynamo or concentrated in a storage battery finds no outlet by radiation. Not all the power of the sun itself could produce an electrical charge strong enough to be conveyed by radiation. It is not strange that those who incline to the ether wave theory of transmission of electrical energy hesitate to admit the solar origin of magnetic storms.

The transmission of electrical energy by conduction, on the other hand, is accomplished with the utmost facility. Telegraphic signals have been conveyed across the Atlantic by means of a proper conducting wire and a battery no larger than a thimble. So too, for the conveyance of power to electric motors surprisingly small quantities of conducting material in the form of wire may be used. The facility of conduction is so great for such vast amounts of power and for such long distances that there is no difficulty in supposing that there may be conveyance from sun to earth provided that the proper medium exists in interplanetary space. The writer has examined a large number of meteorites and has found that they all possess magnetic properties such as would result from subjecting them to long continued induction. Thus the impalpable dust and rarefied vapors of interplanetary space as well as the larger particles and masses of matter, including even the planets themselves, under the conditions of pressure and temperature existing in space, may serve as the means of conduction. Meteoric dust and debris is certainly composed of material that is well fitted for purposes of conduction and gives distinct evidence of having been actually so employed, and it is altogether likely that the low temperature of space and the partial vacuum there existing may facilitate the process.

Conduction like radiation does not involve any transference of material substance. It depends upon the development of stresses in the conducting medium along what are known as lines of force which are not uniformly diffused but extend in particular directions exclusively, just as appears in connection with the behavior of magnetic storms which are originated by impulses conveyed from the sun at a particular angle exclusively. In like manner the concentration of inductive effect at certain poles accounts for the localization of the maximum phases of such storms, which has been described, and there is nothing inconsistent in the fact that this localization should be on the side of the earth away from the sun.

The whole process of the origination of magnetic storms appears to be substantially as follows : Particular portions of the sun's surface and cooler immediate surroundings are electrified by what has every mark of being volcanic action. The motion of rotation of the sun carrying forward these charged portions of its surface develops currents dynamically which act inductively along lines of force wherever there is conducting material within their scope. There is no conveyance by radiation or in a manner similar to that in which heat and light are emitted from the sun. The laws governing the process are entirely different from those of radiation and have reference to the principles of conduction as they appear under the conditions existing in interplanetary space. It is a mode of solar action that is distinct and that must be considered by itself. The final outcome of the temporary, subpermanent and permanent effects of the electro-magnetic impulses thus originated and distributed is a magnetic system comprising within its scope the entire solar system and depending upon the properties of matter rather than of an ether simply. With this clue it becomes possible to trace out the modes of action and reaction and transference of stores of electrical energy in such manner as could not otherwise be done. Following this line of investigation it is already becoming quite certain that electro-magnetic forces play a much more important part in the economy of the solar system than has heretofore been supposed. The physicist who has a clear apprehension of the nature of the properties of matter is the coming man in astronomy. The geometer has had his day. The present purpose will have been served if the proper method of attacking the problems at issue and systematizing observations shall have been indicated.

The paper was discussed by several members.

March 12, 1894.

STATED MEETING.

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

A small number of persons present.

The Council report recommended that a bill of F. A. Steward, for drawing a map of Monroe County and vicinity, to accompany the forthcoming Flora of Monroe County, be referred to two members, with power to authorize payment.

The report was adopted and the chair appointed Mr. J. Y. McClintock and Professor A. L. Baker.

Mr. J. Y. McClintock read a paper:

SOME RECENT ENGINEERING PROBLEMS IN ROCHESTER.

Under reviews in departments of science Miss Florence Beckwith presented the following notes, on Hybridity in Willows.

The study of willows has always been attended with great difficulty on account of the great variety of forms, and the extreme variability of these forms. The question of hybridity has been gradually assuming more importance, and there is a growing belief among botanists that more hybrids occur than was formerly supposed.

In a recent article on "Nithsdale Willows," by Mr. James Fingland, in the Transactions of the Dumfriesshire and Galloway Natural History and Antiquarian Society, this subject is discussed, and from it the following facts are gathered :

In 1838 Sir J. E. Smith, in his "English Flora," said that he had labored thirty years at the task of specific definition, and as a result of his studies gave sixty-four species.

Since that time the estimated number of species has varied according to the opinions of different botanical authors. The last edition of the "London Catalogue of Plants" gave ninety-six forms of British Willows, thirty-one having specific rank, the rest being classed as varieties or sub-species.

Not long since Dr F. Buchanan White published in the Journal of the Linnean Society a work entitled a "Revision of British Willows," in which he introduces a new system of classification, and overturns previous methods. He bases his classification on a recognition of the circumstance of hybridization being an active element in causing the great variability in willows, a fact which the early salicologists were unwilling to admit.

It has been found that binary and ternary hybrids exist spontaneously, and by experiments in cross-fertilization it has been proved that plants could be obtained that represented a pedigree of six species.

Theoretically it is said that any one species of willow may hybridize with any other, but, practically, the number of natural hybrids is limited, owing to different periods of flowering, and non-proximity of many species. In the "Revision" the number of true species is reckoned as seventeen, and the number of hybrids as forty-one, but the latter number has been added to since the author published his work.

Miss Beckwith also presented notes upon the number of species of plants as estimated by an Italian botanist, P. A. Saccardo. The total number now estimated is : Phanerogams, 105,231 ; Cryptogams, 68,475. Total, 173,706.

Miss Mary E. Macauley presented some willow catkins which had developed unusually early, also a specimen of Japanese Witch Hazel, in blossom, from Seneca Park.

Professor A. L. Baker, by means of a diagram, illustrated and explained the perturbed path of the Lexell-Brooks comet, showing the original 6 year orbit of 1770 and 1775, which in 1779 was by the proximity of Jupiter changed into a 34 year orbit which was again, in the year 1846, changed by the attraction of Saturn into a 47 year orbit. This was again, in the year 1886, changed by renewed proximity of Jupiter into a 7 year orbit which brought the comet once more within sight of the earth, the comet having been lost in 1779 and recognized in 1889 after much laborious calculation as the long lost comet of 1770 and 1775.

APRIL 9, 1894.

STATED MEETING.

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

A small audience present.

The Secretary read the following paper:

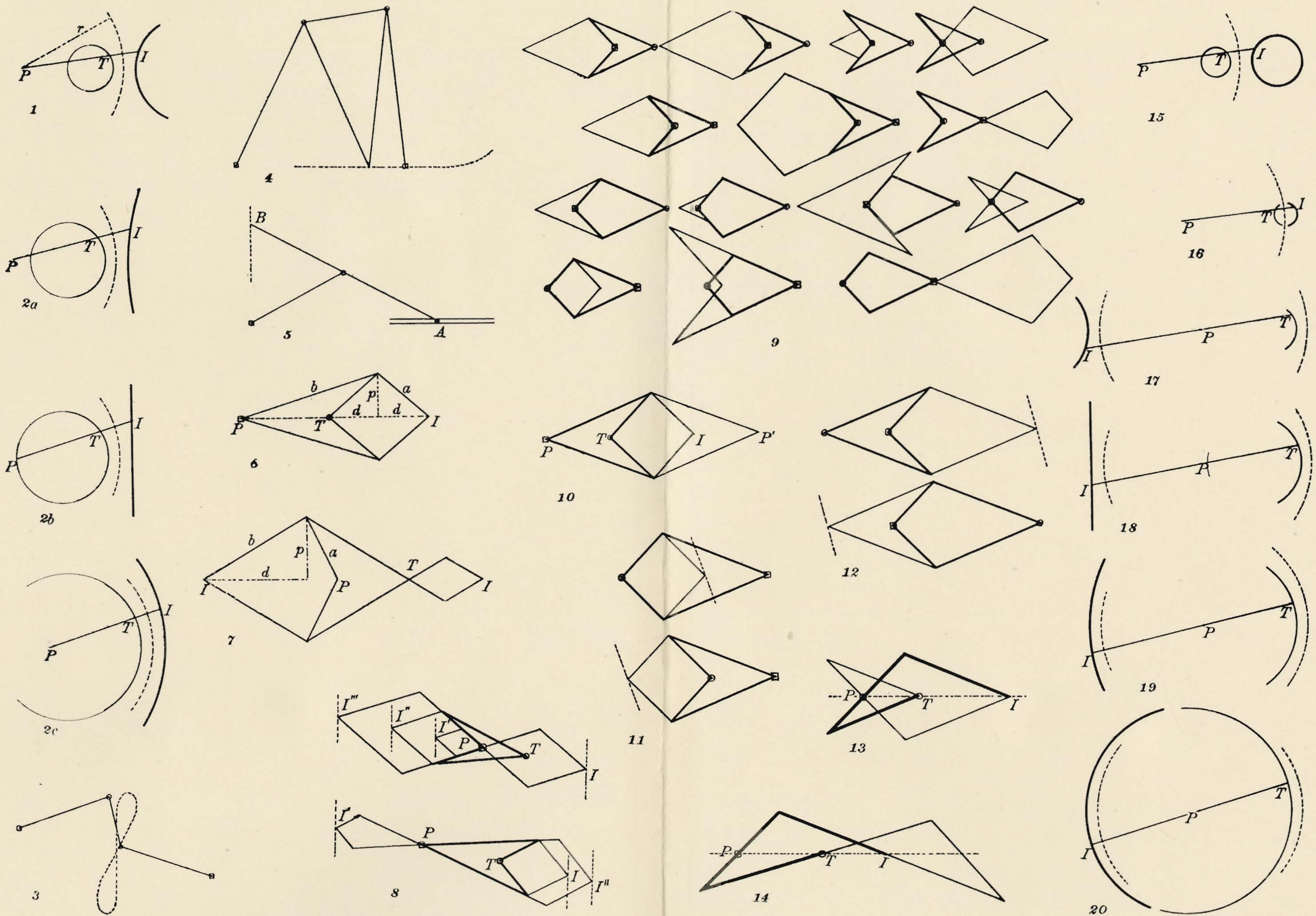
CIRCULAR INVERSION AND ITS BEARING ON THE PEAUCELLIER CELL AND THE STRAIGHT LINE.

BY ARTHUR L. BAKER.

If you will throw your memories back to the days of your geometry, you will recall a theorem which runs in this wise:—If from a fixed point without a circle a secant is drawn, the product of the secant and its external segment is constant in whatever direction the secant is drawn, and is equal to the square of the tangent from the point to the circle.

Like most of the theorems of elementary mathematics this is a degraded case of a far more general theorem which runs as follows:— For every point on one side of a central curve called the curve of inversion, there is a corresponding point on the other side such that the product of the distances of the two points from the centre is equal to the square of the radius vector which passes through the two points, and to every curve traced by the one point corresponds a curve traced by the other point, called the inverse of the traced curve.

We will consider only the special cases of the curve of inversion



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2a
2b
2c
3
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10
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13
14
15
16
17
18
19
20
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T
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r
B
A
b
a
p
d
P'
I'
I''
I'''

and the traced curve being circles, in which case the inverse curve is also a circle, as is shown by substituting in the polar equation of the circle

$$\rho^2 - 2\rho a \cos\theta + a^2 - r^2 = 0,$$

$\frac{k^2}{R}$ for ρ, since $\rho R = k^2$, ρ being the radius vector of the circle to be inverted, and R the radius vector of the curve of inversion.

This substitution gives

$$R^2 - 2R\frac{k^2 a}{a^2 - r^2}\cos\theta - \frac{k^4}{a^2 - r^2} = 0,$$

which is evidently the equation of a circle also.

This will be better understood after a glance at fig. 1, (plate 12) where P is the centre of the circle of inversion, T the tracing point, and I the inverse of the point T, r being the radius of the circle of inversion. Here $PT \cdot PI = r^2$. The curves traced by P and I are also shown, both being circles. Fig. 2 shows the effect of enlarging the radius of the circle traced by T, the dexter vertex of the horizontal diameter of T being fixed. You will notice that as the circle T enlarges, the circle I also enlarges, only much more rapidly, and finally its arc becomes a straight line, and then begins to curve the other way. I is a straight line when T passes through the centre of inversion. This is shown by making $r = a$, in which case the equation above becomes

$$R \cos\theta = \text{constant},$$

the equation of a straight line.

Now if we can only harness P, I and T together by some mechanical contrivance, so that the product $PI \cdot PT$ shall be constant, it will only be necessary to make T move in a circle *through* P to get I to trace a straight line.

The importance of this will be appreciated when I state that previous to the year 1864 there was no known method of tracing a straight line primarily by the continuous sweep of a tracing point. By primarily I mean without first having some other straight line as a guide. I do not mean to say that there were no straight lines previous to 1864, but they were drawn by means of a straight edge which had been previously constructed by trial, taking off "here a little, there a little," until finally it satisfied the eye of its maker. You will appreciate the significance of this if you try to construct a circular ruler by cutting a circle as near as you can and then correcting it by trial until you have a satisfactory result. Practically you would not do this, but would describe your circle with one sweep of the tracing point of a pair of compasses.

To accomplish the same thing in the case of a straight line had long been the object of mechanicians from the days of Watts on. The problem was usually spoken of as that of parallel motion. Watts accomplished it partially by means of the mechanism shown in fig. 3, where the line traced (dotted) is shown nearly straight on one side of the figure 8, but decidedly not straight beyond certain limits. In this mechanism the short arm is perpendicular to the two equal radial arms when they are parallel. Later, Richard Roberts of Manchester devised the linkage shown in fig. 4, in which the distances between the fixed points is twice the distance between the two movable pivots, the long arms being of equal length. The fixed pivots are designated by □ and the movable pivots by o. Within limits, as shown, the line is nearly straight. Other methods have been devised but they either merely approximate, or else depend upon straight line guides, as in the parallel motion of Scott Russell shown in fig. 5, where the point *A* slides in guides, as shown, and the point *B* describes the straight line.

Finally, in 1864, Peaucellier, a French officer of Engineers, devised the mechanism shown in skeleton in fig. 6, in which $PT \cdot PI =$ constant, *T* and *I* being opposite vertices of a rhombus. To show that this product is constant, consider that

$$b^2 = p^2 + (PT + d)^2, \quad \text{and} \quad a^2 = p^2 + d^2, \quad \text{whence}$$
$$b^2 - a^2 = (PT + d)^2 - d^2$$
$$= (PT + 2d) \cdot (PT) = PI \cdot PT = \text{constant},$$

since the arms *a* and *b* are invariable in length.

Now if *T* be constrained to move on a circumference through *P*, *I* will, as we have just seen, describe a straight line. A radial arm connecting *T* with a fixed point equidistant from *P* and *T* would accomplish this.

In this machine we have the famous Peaucellier cell. If you wonder at the word cell, I must refer you to the International Dictionary where you will find—Cell : The space between the ribs of a vaulted roof ; or to Murray's New English Dictionary—One of the number of spaces into which a surface is divided by linear partitions ; one of the compartments into which anything is divided.

As a modification of this, take any point I', fig. 7, by constructing the rhombus $I'T$, similar to TI, and connect the point *P* as shown.

Then just as in the previous figure, $b^2=p^2+d^2$, $a^2=(d-PT)^2+p^2$, and $b^2-a^2=d^2-(d-PT)^2$

$$=(2d-PT)\ PT=PI'\cdot PT=\text{constant}.$$

Hence I' will describe a straight line.

The point I' is evidently connected with the former cell by enlarging or diminishing, even through evanescence, the rhombus TI.

Several tracing points can be had in the same cell, as shown in fig. 8, where the points I, I', I'', I''' all describe straight lines, as shown. The points I', I'', etc., are evidently found by increasing or diminishing, even through evanescence, the tetragram PI.

From this we get a rule for constructing a Peaucellier cell.

Construct a double isosceles tetragram (not a rhombus) with one vertex fixed (the pivot) and the other vertex constrained (by a radial arm) to move on a circle through the pivot. On the pivot legs construct another tetragram forming a rhombus with the other pair of legs. The vertex of this second tetragram will describe a straight line. This second tetragram can be enlarged or diminished, even through evanescence.

In fig. 9 I have drawn the cells resulting from the application of of this rule. □ indicates the pivot P, and o the point T traveling on the arc of a circle through the pivot.

If to the single cell we add another pair of arms so as to form a rhombus with the pivot arms, we get the double cell of fig. 10. Since P' is symmetrical with P, and $PT\cdot PI=$ const., $P'I\cdot P'T=$ const., and P' may be taken as the pivot and either T or I as the circle tracing point (see fig. 11). By taking T as the pivot and applying the rule for the construction of cells we get $TP\cdot TP'=$ const. (fig. 12). If we have the cell shown in fig. 13, in which $PT\cdot PI=$ const., and remove the light arms, replacing them as shown in fig. 14, the geometrical relation between the points P, T, and I will not be altered, nor will their mechanical connection be lost, and we will have a cell of four arms instead of six as heretofore. From the symmetry of the figure $II'\cdot IT=$ const., $IP\ II'=$ const., $TP\cdot TI'=$ const., as in the double cell.

Various modifications of this cell or linkage as it is sometimes called have been devised for different purposes, a short account of which will be found in Kempe's "How to Draw a Straight Line."

Before closing, permit me to call your attention to one phase of circular inversion that will show more clearly how your early theorem in Geometry is connected with the inversion diagrams that I have already shown you.

In fig. 2, I supposed the circle T to enlarge toward the left, the dexter vertex remaining fixed. I shall now let the circle diminish, the dexter vertex being always fixed. The circle I will also diminish as shown in fig. 15. This diminution will continue until both become points at the same moment. Then as the sinister vertex of T passes through the dexter vertex *to the right*, I begins to enlarge to the *left*, and finally T and I coincide, as shown in fig. 16, and we have the case of the geometries :—The product of the segments of a pivoted secant is constant.

So far I have spoken only of what might be called positive inversion, that is, inversion where the distance PI is laid off *along* the line PT. If the distance PI be laid off *backward* instead of along PI, we get what might be called negative inversion, which differs from the case we have been considering in that the I circle appears on the left of the curve of inversion in an exactly symmetrical position to that for positive inversion.

Thus figs. 15 and 16 would become figs. 17 and 20. Figs. 18 and 19 show the intermediate steps.

Fig. 20 brings us to another familiar theorem of Geometry, viz.: If any chord is drawn through a fixed point within a circle, the product of its segments is constant.

You will notice the close connection between these two elementary theorems of Geometry, a connection which the geometries fail to bring out, but which could be very plainly shown, even in elementary works, if the two theorems were combined into one, as follows :—

The product of the segments of a pivoted secant made by the pivot (internal or external) is equal to the square of the line from the pivot to the circle, the line being perpendicular to a diameter through its extremity. If the pivot is internal the diameter will pass through it ; if external the diameter will pass through the end of the line which is on the circle.

For the case in which I is a straight line, those interested in mathematics will recognize a special case of *pole* and *polar*, for which many interesting correspondences might be drawn.

Hon. Martin W. Cooke discussed and illustrated with diagrams the law of the ellipse described by a body thrown from a revolving planet.

APRIL 23, 1894.

STATED MEETING.

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

Twenty persons present.

Under the call for notes in departments of science, the following two papers were read :

A BIOGRAPHICAL SKETCH OF DR. SAMUEL BEACH BRADLEY.

BY FLORENCE BECKWITH.

Dr. Bradley, if not the earliest, was certainly one of the earliest botanists of this section of country, and it is thought proper that the Academy should put on record some of the facts of his life, since his work was done in this vicinity, and we possess a portion of his herbarium, the gift of Dr. D. G. Hastings, of this city.

As a botanist Dr. Bradley had a wide reputation. He is often quoted as an authority in catalogues of plants, and in Gray's Botany (5th edition) he is mentioned in like manner. The period of his work is covered by the years of his residence in Monroe county, or from 1825 to 1880.

He was a close and accurate observer, and his work along the lake shore and the inlets and ponds adjoining was particularly thorough. Some of the plants he found here have since become extinct, or, at least, have never been reported by any other botanist, and many others are now extremely rare. In "Paine's Catalogue of Plants of Oneida County and Vicinity," published in 1865, Dr. Bradley is given as the sole authority in this vicinity for twenty-one species of plants. In the list of plants of Monroe and adjoining counties which this Society is soon to publish, there are eleven species credited to Dr. Bradley alone, no other local botanist having observed them. *Limnobium spongia* was reported by him as found in Braddock's bay, but has not been seen by any later botanist, although sought for. During the 1892 meeting of the American Association for the Advancement of Science the visiting botanists spent an afternoon in the locality without finding the plant.

For the following sketch of Dr. Bradley's life, we are indebted to Mrs. Annie Hastings Gott, whose family were his life-long friends.

Samuel Beach Bradley, son of the Rev. Joel and Mary Anne

Beach Bradley, was born in Westmoreland, Oneida county, N. Y., in August, 1796, and died at his home in West Greece, Monroe county, in September, 1880, at the age of 84 years.

He graduated at Union College, Schenectady, in 1814, and then studied medicine with Dr. Seth Hastings, of Clinton, Oneida county. Dr. Hastings had an extensive botanical garden for the special use of his students, and it was here that Dr. Bradley became interested in botany, and he made a thorough study of the local plants.

Dr. Bradley practised medicine for a time in Eaton, N. Y., and at the age of 21 he married Miss Cornelia Bradley, whose death a few months after their marriage shadowed his life for many years. At this time he gave himself up to the solace of his books, especially to the languages, both modern and classical, and during his whole life, up to his last illness, he daily read some portion of Scripture in both Greek and Hebrew.

He came to Parma, N. Y., in 1820, and in 1823 was a member of the Assembly. He settled in West Greece, Monroe county, in 1825. He used to say that at that time Greece was infinitely more attractive in every way than the settlement that has grown to be Rochester, and as the Ridge Road had begun to be settled, it seemed to offer much better inducements to a physician. It was about this time that he began his botanical work in this section, and it was his delight to explore every swamp and woods for rare plants. He kept up his interest in botany as long as he lived, and the last few months of his life were devoted to naming and rearranging the specimens in his herbarium. He corresponded with many eminent botanists of his day, and he is often quoted as an authority on the plants of this vicinity. The greater part of his herbarium was given after his death to the Northwestern University, Evanston, Illinois.

Dr. Bradley's love for books was one of his characteristics. He was a very correct Latin scholar, and gave much time to the best authors. He had a very large collection of the best French authors, and also read with ease German and Italian. He had also studied Sanskrit, Arabic and Anglo-Saxon. He was an earnest student of history, and a most indefatigable reader of the best literature, both modern and classical.

In character Dr. Bradley was a perfect type of a Christian gentleman. He had a warm sympathy for all who suffered, and a broad charity which made him kind to all alike, no matter how unworthy. He was the trusted friend and counselor of many who else had been friendless. His long residence in Greece gave him an intimate knowledge of nearly every family and person for miles around, and he was loved and honored by all who knew him. In person he was rather stout, with broad shoulders and a beautiful head. His forehead was broad and high, and his eyes were dark and brilliant, lighting up as he became interested in conversation. His whole countenance was very expressive. His manners were cordial and his hospitality unbounded. Notwithstanding all his book-lore, he never seemed to lack interest in even the most humble or commonplace person who laid claim to his attention. He was especially interested in the young, and was always ready to help any student. For many years he taught a Bible class, or, in the absence of a pastor, conducted services in the Congregational church. Cheerfulness, love of humor, ready wit and quick repartee were among his prominent characteristics. His intellectual life was intense and vigorous.

In 1831 he married Mrs. Sarah Bartlett Crane. His three children are Miss Cornelia Bradley and Mrs. Gilbert Cromwell, of Ogden, and Dr. William Bradiey, of Evanston, Illinois.

The President read the following paper :

THE LENGTH OF GEOLOGIC TIME.

BY HERMAN LEROY FAIRCHILD.

The problem of the Earth's age has a peculiar interest, none the less from its uncertainty, and improbability of exact solution. The most frequent question asked the geologist is one relating to time. How many years ago was this or that event or phenomenon ?

The problem has been approached from two directions ; by the geologists, basing estimates upon the present rate of land destruction and marine sedimentation, as applied to the total thickness of sedimentary rocks ; and by the physicists, calculating from the laws of matter and radiant energy the time required for cooling and condensation of the earth. The geological method, resting upon the theory of uniformity, is simple, but the data are complex and elusive ; the physical method has to make large assumptions regarding the behavior of matter under conditions of heat and pressure transcending all experience.

Estimates upon the length of geologic time have been made by many geologists. When the uniformitarian theory came into general acceptance, a half century ago, and it was recognized that the earth, as we see it, is the result of steady action of the same geologic forces and agencies that are working to-day, it was naturally believed that the age of the earth must be of indefinite duration. For merely the sedimentary rocks a minimum time of hundreds of millions of years was claimed. For the pre-Silurian and crystalline rocks, and the preceding molten stage of the earth no limit could be given. This was the inevitable swing of the intellectual pendulum away from the catastrophic or cataclysmic theory and the Biblical chronology.

To these extreme views a check was given by the physicists. In 1862 Sir William Thompson challenged the geologists by announcing that from the laws of heat radiation not over 100 millions of years could be allowed for the cooling of the earth to its present condition from a fluid state. Other physicists later gave much less range of time. The geologists were led to moderate their claims, and to make closer estimates, until now there is substantial agreement between the two classes of scientific men.

By a comparison of the character and amount of sediments the relative lengths of the great geologic time divisions are not difficult to approximate. But a determination in years is difficult because of the lack of any constant quantity with time value. As a time unit various phenomena have been taken ; the rate of degradation of the continents ; the growth of river deltas ; the formation of river canyons ; and the amount of rock disintegration and stream erosion since the ice invasion in our northern lands. The results are confessedly inexact, but have a fair agreement.

In the past year three important essays upon the subject have appeared, one from the physical standpoint, and two from the geological. In the January, 1893, issue of the *American Journal of Science*, Mr. Clarence King revises the physical conclusions in the light of new data upon the behavior of diabase rock under experimental conditions of heat and pressure. His conclusion is that the age of the earth since its molten state cannot be over 24 million years. An article by Mr. Warren Upham in the March, 1893, number of the same journal, reviews the arguments and estimates of earlier writers, and favors 48 million years for our stratified rocks (since beginning of Cambrian time), or 100 millions for geologic time (since the ocean existed). The Vice-Presidential Address of Mr. C. D. Walcott before Section E of the American Association for the Advancement of Science, at Madison, Wisconsin, in August last, was printed in the *American Geologist* in December. By a careful and detailed study of the sedimentary rocks of Paleozoic time in western America as a basis for comparison and computation, and modifying the time ratios of Haughton and Dana, he concludes that post-Archean time is between 25 to 30 million years as a minimum, and 60 to 70 million years as a maximum. More definitely he gives 27,650,000 years for the fossiliferous rocks and 55 million years for geologic time (since the beginning of the Archean).

Following is a table of estimates of various writers, the physicists placed last. The first column gives those estimates which cover only the time of the fossil-bearing or unaltered sediments, that is, since the beginning of Cambrian time. The second column gives those estimates which include all of "geologic time," that is, since the beginning of the Archean, or since the present agencies began their work. This time would be covered by the existence of the ocean. The third class of estimates are those which cover all the duration of the earth since a state of extreme heat. The estimates of the physicists fall into this third class.

		For fossiliferous sediments.	For existence of ocean.
(1)	Sir Charles Lyell	240 million years.	
(2)	Dr. Samuel Haughton	133 " "	200 million years
(3)	Dr. James Croll	60 " "	72 " "
(4)	Dr. Charles Darwin		200 " "
(5)	Sir Alfred Wallace		28 " "
(6)	Sir Archibald Geikie	100 " "	
(7)	Mr. T. Mellard Reade	95 " "	
(8)	Prof. J. D. Dana	48 " "	
(9)	Prof. Joseph LeConte	30 " "	
(10)	Mr. Warren Upham	48 " "	100 " "
(11)	Mr. C. D. Walcott	28 " "	55 " "
(12)	Mr. W. J. McGee	2400 " "	

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(1) Lyell :—"Principles of Geology," 10th Ed., 1867, Vol. 1, p. 301.
(2) Haughton :—"Six Lectures on Physical Geography," 1880, p. 94; *Philos. Mag.*, XXVI, Dec., 1877, p. 545.
(3) Croll :—"Climate and Time," 1875, p. 342.
(4) Darwin (Chas.):—"Origin of Species," 5th Ed., 1871, p. 291.
(5) Wallace :—"Island Life," 2d Ed., 1892, pp. 222–223.
(6) Geikie :—"Presidential Address," 62d Meeting Brit. Assoc. Adv. Sci., 1892; (*Nature*, Aug. 4, 1892, and in *Smithsonian Report* for 1892).
(7) Reade :—*Geological Magazine*, Vol. 10, 1893, pp. 99–100.
(8) Dana :—"Manual of Geology," 3d Ed., 1880, pp. 590–591.
(9) Le Conte :—"Elements of Geology," 1888, pp. 275–276.
(10) Upham :—*Amer. Jour. Sci.*, Vol. XLV, March, 1893, pp. 209–220.
(11) Walcott :—*Amer. Geologist*, Vol. XII, December, 1893, pp. 333–368.
(12) McGee :—*Science*, June 9, 1893, p. 309.

		Since molten state.		
(13)	Prof. A. de Lapparent	80	million	years.
(14)	Dr. Alexander Winchell	3	"	"
(15)	Sir William Thomson	100	"	"
(16)	Prof. George H. Darwin	57	"	"
(17)	Prof. Guthrie Tait	10	"	"
(18)	Prof. Simon Newcomb	14	"	"
(19)	Mr. Clarence King	24	"	"

Excluding the two extreme estimates in the above table, it will be seen that the late estimates are in fair agreement and, as compared with former views, are reasonably definite. There is substantial agreement not only among the geologists, but between the geologists and the physicists.

Estimates of the relative duration of the greater geologic time divisions have been made as follows :

	Paleozoic.	Mesozoic.	Cenozoic.
Dana	12	3	1
Winchell	9	3	1
Williams, H. S.	15	3	1
Walcott	12	5	2

Mr. Walcott's estimate, according to his proportion given above is, for the Paleozoic, 17,500,000 years ; Mesozoic, 7,240,000 years ; Cenozoic, 2,900,000 years ; total for the fossiliferous sedimentary rocks, 27,650,000 years.

The time since the departure of the ice of the Glacial period from this portion of the continent has been estimated by several eminent authorities, from different data, and their figures fall within 6,000 to 10,000 years.

Mr. F. W. Warner described a new ammonia motor now constructing in New York city.

A letter from Dr. M. A. Veeder was read, relating to the co-operation of the telegraph companies in transmitting reports of auroras and electric disturbances.

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(13) de Lapparent:—*Bull. Soc. Geol. France*, 3d Ser., Vol. 18, 1890, pp. 351-355.
(14) Winchell:—"World Life," 1883, p. 378.
(15) Thomson:—*Trans. Roy. Soc. Edinburgh*, Vol. XIII, Pt. 1, p. 157; "Treatise on Natural Philosophy" (Thomson and Tait), Appendix D.
(16) Darwin (G. H.):—*Phil. Trans. Roy. Soc.*, Pt. 2, 1879.
(17) Tait:—"Recent Advances in Physical Science," 3d Ed., 1885, p. 169.
(18) Newcomb:—"Popular Astronomy," pp. 505-519.
(19) King:—*Amer. Jour. Sci.*, Vol. XLV, January, 1893, pp. 1-20.

Dr. C. T. Howard exhibited specimens of buds and leaves infested by the bud moth (*Tinetocera ocellana*).

The President referred to Circular No. 3 of the Department of Agriculture relating to the Scale insect (*Aspidiotus perniciosus*) which has become troublesome in the Eastern states.

MAY 14, 1894.

STATED MEETING.

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

Forty-five persons present.

The Council report announced that at the next business meeting an election would be held to fill the vacancy in the office of Second Vice-President, caused by the death of Dr. M. L. Mallory, and recommended that the Academy give its support and co-operation to the movement initiated by the Scientific Alliance of New York City to secure lower rates of postage on scientific material. The recommendation of the Council was adopted.

Mr. J. Y. McClintock exhibited a photographic copy of a topographical map of Rochester and vicinity made by the co-operation of the United States Geological Survey and the New York State Engineer and Surveyor. Later in the evening, the following resolution, introduced by Mr. McClintock, was adopted :—

Resolved, That the Rochester Academy of Science urges upon the State Engineer and Surveyor, and the Director of the United States Geological Survey, the desirability of making the "Rochester Sheet" of the New York State Topographical Map cover the territory northward to the shore of Lake Ontario, so as to include the shore line entirely across the sheet.

The following memorial sketch of Dr. M. L. Mallory, Second Vice-President of the Society, was then read :

A MEMORIAL OF MAITLAND L. MALLORY, M. D.

BY WILLIAM STREETER.

When an esteemed citizen in public life is removed from the field of his labors all have a sense of individual loss. The Rochester

Academy of Science has suffered such loss in the sudden demise of a Vice-President, one of its oldest and most honored Fellows, an officer of sound judgment and rare executive ability.

We have not yet sufficiently recovered from the shock which the tidings of Dr. Maitland L. Mallory's death occasioned, to speak of it but in sighs and sorrowful ejaculations. I shall not attempt any extended eulogy, but merely call to mind a few of those traits of character which won for him a place so dear in the hearts of his friends and associates.

Through the daily press we have become familiar with the story of his early life, and some of his later achievements, but while he was admired and respected by all who knew him for his many good qualities, it was only to his most intimate friends that he was fully revealed. We who have had the pleasure of working with him on different lines of investigation, have invariably found him imbued with the true scientific spirit—a close observer, a deep and clear reasoner, an ardent lover of Nature, whose aim it was to understand thoroughly her methods, and possessing so many of her secrets, yet too great and too well aware of the vastness of the unknowable to be at all vain or conceited. I have often been surprised at his knowledge of sciences to which he made no claim as a specialist.

An enthusiastic student, his library outside of his professional literature embraced most of the standard, technical works in a wide range of subjects, especially in the fields of microscopy. A man of rare and refined tastes, his standard was exalted, and the true and beautiful alone attracted him.

With ample means at his command and a generosity which caused him to do more than his full share in any enterprise where money was required, he would shoulder the greater part of the burden in such a way as to relieve all from embarrassment, as the Microscopical Section will bear me witness.

While fond of out-door sports, and with steady nerve and unerring eye, he was in sportsman's phrase "a dead shot," it was as a naturalist, and not as one who simply "goes a-killing" and ruthlessly slaughters everything in his path. More in the interest of science than of sport he would carefully select a fine specimen and bring it down, while others of its kind would pass under his immediate notice, unharmed. So while in the true sense a hunter he was in no sense a wanton destroyer of the denizens of the forest.

Though born upon British soil, he came to the States as the home of his adoption and was an American citizen in the full meaning of the term, a lover of the republic and of republican institutions.

He took a lively interest in all that pertains to the elevation and enlightenment of the masses. A true philanthropist, his chosen profession was for the alleviation of suffering humanity. His skill and untiring efforts have restored to health and happiness hundreds who survive to honor his memory. The Monroe County Medical Society, the New York State Medical Society, the Pathological Society, the City Hospital, the Western New York Institute for Deaf Mutes, the Rochester Board of Health, alike lament the untimely removal of one, for many years so closely identified with their interests.

The plans which he developed for the systematic study of our water-supply, if fully carried out, would be of very great importance to the city of Rochester, and would place upon record facts and data which might be the means of tracing disease and epidemics, and would place within easy reach a means of comparison for all future time.

His work in scientific research was methodical and painstaking, and his reputation far exceeded local bounds, as his connection with the American Microscopical Society, the British Royal Society of Microscopy and the American Association for the Advancement of Science bears witness.

A warm friend of Dr. Mallory recently wrote :—" His youth and early manhood were not free from adversity, which was nobly met and valiantly conquered. The struggles of youth gave way to the successes of manhood, and there was developed a finely-rounded and symmetrical character. His mental endowment was of that cumulative kind which could rapidly take up new pursuits and almost intuitively absorb their substance and master their details. This was true in many and widely diverse directions. A casual observer could not form an idea from his calm and dignified manner of his manifold acquirements. It was only as one became better acquainted with him that he was really appreciated, and to those who knew him best his life for many years was a constant inspiration to higher achievement."

Physician, philanthropist, scientist, scholar, patriot, citizen, comrade and friend, we shall miss the words of greeting, warm from thy heart, we shall miss thee from the familiar walks of life, and the entire community is indeed bereft! From the depths of overflowing hearts we may truly say as did Antony of the noble Roman,—

> " His life was gentle and the elements
> So mixed in him that Nature might stand up
> And say to all the world, ' This was a man.' "

The following resolution was offered by Dr. J. Edward Line:

"Resolved that the memorial of our late fellow member, Dr. Maitland L. Mallory, as prepared and read by Major William Streeter, be and hereby is adopted as the sentiment of this Society; that this memorial be spread upon the minutes, and printed in the Proceedings of the Academy; and that copies be sent to the American Association for the Advancement of Science, the American Microscopical Society, and the Royal Microscopical Society, London, of which societies Dr. Mallory had long been a member."

In seconding this resolution personal tributes to the character and works of Dr. Mallory were offered by Mr. J. Y. McClintock, Professor S. A. Lattimore and Dr. George W. Goler, former associates of the deceased physician. These tributes referred particularly to his work upon the City Board of Health, and to his generous interest in many institutions and charities.

The resolution was unanimously adopted.

The following paper was read:

THE RECENT EPIDEMIC OF TYPHOID FEVER IN BUFFALO.

By S. A. Lattimore.

About the beginning of last March the attention of the Department of Health of the City of Buffalo was attracted to the fact that an unusually large number of cases of typhoid fever were being reported by physicians. The number increased daily, reaching one hundred and twenty-two on the eleventh. Suddenly the presence of an epidemic was recognized. Through the press the distressing news was immediately conveyed to the whole city. Anxiety became alarm, and alarm soon became panic. Without the slightest warning, and from an utterly unknown source, a city of three hundred thousand people found itself suddenly invaded by a pestilence, striking down its victims in nearly every quarter, and respecting no rank or class. Every inhabitant was menaced. Three questions sprang simultaneously from every lip :—Whence came this pestilence? When will it cease? What can be done? And there was no answer.

Of this epidemic I have been asked to give the Academy of Science a brief account. I have accepted the invitation with hesitation because I am well aware that any account I can give you will be more or less imperfect from the lack of some, and possibly many, of the data essential to a complete history. And yet it seems to me that a study of this case, even in its broader outlines may be useful, not because it has contributed any new facts to sanitary science, but because it powerfully emphasizes the importance of putting to practical use the knowledge we already possess.

The study of an epidemic is usually involved in great difficulty. When it attracts the attention, it is often too late to ascertain the causes and conditions from which it sprang ; they have either ceased or changed, leaving no certain trace, and relegating us to conjecture and inference. When, as in this case, it is possible to trace the causes to their natural results, and make out a complete history of the epidemic from its beginning to its end, it constitutes a most important contribution to sanitary science, as it shows us the true means of prevention, which is the great object to be sought.

Epidemics have been noticed in history ever since history began to be written, but never seriously and scientifically studied until very recently. In former ages people cowered in helpless and hopeless terror before the pestilence. It walked in darkness, there was no search light to turn upon it. It was the unapproachable mystery, the embodiment of divine, omnipotent and indiscriminate fury. What a change has taken place ! Does cholera break out in India, the leading nations of the world dispatch their most learned and intrepid scientists to study it where it rages most violently. Does yellow fever, the terrible legacy left to the white race by the African slave trade, rage in tropical ports, thither flock the heroic students to study its causes and its nature. On the discoveries thus made must be based all intelligent means of prevention by disinfection and quarantine.

Thus it is that sanitary science is pre-eminently a coöperative product. It is the final result of many distinct but contributing sciences. Singularly, too, it is largely the direct outcome of calamity and disaster. The sanitary legislation of England, beginning only forty years ago, which has already so largely blessed the entire civilized world, found its incentive in the Crimean war. The sanitary movement in this country, ten years later, leading to the organization of state boards of health, and enabling us repeatedly to defy and baffle the approach of the most destructive epidemic of modern times, originated in the awful experiences of the southern rebellion. Thus we profit by the hard experience of our ancestors.

The recent epidemic of typhoid fever in the city of Buffalo is noteworthy as an instance in which nearly, if not all, the data necessary for a complete history, as to its cause, its progress and its cessation, were collected and studied on the spot and at the time by competent scientific observers. Such a history, I have no doubt, will ultimately be furnished from official sources.

A brief visit to the city of Buffalo at the height of the epidemic afforded me the opportunity of learning most of the facts presented in this account, from officers of the Department of Health, from a number of leading physicians and prominent citizens. Some of the gentlemen have kindly furnished additional information since the cessation of the epidemic.

A clear comprehension of the cause of this outbreak requires some knowledge of the following facts. The waters of Lake Erie flow northward through the Niagara river. On the eastern bank of this river and at its origin lies the city. The main water-supply of the city is derived from the river at a point almost opposite Fort Porter. Just below the Fort is the pumping station from which a tunnel extends under the river, terminating at "the crib," which protects the inlet, and is situated near the middle of the stream. Near the eastern shore, at Bird Island, another inlet communicates with the tunnel. (A diagram was exhibited and explained.) The reservoir is of small area and is not depended upon for storage purposes, but rather to equalize the pressure maintained by the pumping engines, which are driven without intermission. The daily consumption averages about seventy-five million gallons. The distributing mains are so constructed that a direct distribution from the pumping station is secured, while but a small part of the water ever enters the reservoir. The circulation in the mains is therefore necessarily and constantly active. The inlet is approximately opposite the middle of the city on a north and south line. A large area of the southern part of the city, embracing Buffalo creek, the Hamburg canal and the city ship canal leading from the coal, lumber and railway docks, discharges its sewage into the river *above the inlet.* As the current is rapid, the sewage is carried down along the eastern shore, and, at least in theory, is not supposed to reach the middle of the river where "the crib" is situated. The Bird Island inlet, however, lies full in its way, but is kept closed. All these facts bear upon the history of the case.

The epidemic prevailed from the beginning to the end of March. During these thirty days the total number of cases reported was four hundred and fifty-three and considering the difficulty of obtaining complete statistics in such cases I think we may reasonably conclude that this epidemic produced a thousand cases of typhoid fever. Happily the number of fatal cases was small.

No sooner was the presence of an epidemic recognized than a vigorous and intelligent search for the cause was instituted as the necessary preliminary to any rational scheme for its abatement. Guided by the bacterial theory of the origin of typhoid fever, attention was directed at once to the water-supply. The following facts were discovered. During the latter part of February strong winds from the north or northeast had been prevalent, setting back the water in Lake Erie, and lowering the level of Niagara river so much that the quantity entering the tunnel at "the crib" was greatly diminished. Consequently the supply in the reservoir was being rapidly exhausted on account of its small capacity, and the pressure was being reduced to so low a point as to cause serious apprehension in the event of a conflagration. Most unfortunately, and most unaccountably, in this emergency, the gates of the unused inlet at Bird Island, on the east side of the river, were opened and the sewage-laden water was pumped into the mains of the city, and the requisite fire-pressure secured. This event, it will be observed, preceded the outbreak of the epidemic approximately by the ordinary period of incubation for the typhoid bacillus. To transform the theory into a demonstration, if, indeed, any were needed, and to render the chain of evidence complete, Dr. William G. Bissell, Acting Bacteriologist to the Department of Health, not only detected Eberth's *Bacillus typhosus* in water taken from the city mains March 7th, but successfully cultivated it in various media.

A significant fact was observed during the period of the epidemic, that in those parts of the city to which the water mains had not been extended, and where, in consequence, ordinary wells are in use, and also in a section supplied from artesian wells, no case of typhoid fever was reported.

I call your attention to a map of Buffalo on which the location of each reported case is accurately marked. A study of this map is more impressive than any verbal description could possibly be. I am indebted to the courtesy of Dr. Ernest Wende, Health Commissioner, for its loan from his office.

At the beginning of the epidemic the Department of Health fully recognized the gravity of the situation, and the imperative necessity of discovering and applying a prompt and intelligent remedy. The Academy of Medicine was on the alert, and appointed a number of the leading physicians of the city as an advisory committee to coöperate with the officers of the Department of Health. These movements of officials and scientific men naturally and unavoidably intensified the public alarm. Bulletins of advice were issued by the Health Commissioner for the instruction of the citizens, in which was urged the importance of sterilizing all water used for domestic purposes. The Superintendents of all railways entering the city were warned against the danger of supplying passenger cars with water from the city mains. The faucets in the public schools were ordered closed, and the children carried from home bottles of sterilized water.

The situation prompted such questions as these :—How long will the epidemic probably continue ? May not this be only the beginning rather than the culmination or the end of the pestilence? In view of the fact that the many miles of water mains, and possibly the reservoir itself, were now thoroughly infected, and that the *Bacillus typhosus* is capable of living and multiplying in water at ordinary temperatures, and might thus take up its permanent abode there, no reassuring answers to such questions as these could be given. The forecast was truly gloomy if not threatening. The demand that something should be done to arrest the ravages of the epidemic was urgently pressed upon the health authorities. Meanwhile they and their advisers were earnestly considering the question,—What can be done? Before a solution of this problem could be reached there were happy indications that the pestilence had passed its culmination and was unquestionably abating. The number of cases reported declined daily, until by the end of the month the normal rate had been reached, and the epidemic had ceased.

This sketch would not be complete without allusion to a method of disinfection novel in its method, and unusual in its magnitude. Although the trouble appeared to have passed, a return was still feared, and it was determined to attempt the disinfection of the reservoir. To this end, it was completely emptied, and a solution composed of eighty-five pounds of liquid bromine, dissolved in twelve thousand gallons of water, was applied to the walls and floor of the reservoir with the full power of a steam fire-engine, the engineer keeping well to the windward.

Allow me now to summarize very briefly the significant facts already stated somewhat in detail :

In the month of February, by an amazing blunder, water beyond all question sewage-laden, was pumped into the mains and used by the unsuspecting citizens. Almost immediately after the contamination of the water, as I am credibly informed, "nearly every one in the city was more or less ill with dysentery accompanied with griping pain in the bowels, and a rise of temperature to about 103°. In two or three days this subsided." At the beginning of March the epidemic was recognized, reaching its maximum daily number reported, 122 cases, on the eleventh, and declining through the next twenty days. A condition inseparable from every case was the use of water from the city supply. Others escaped without exception. The chemical analysis of the water by the City Chemist, Dr. Herbert M. Hill, showed evidence of contamination. The bacteriological examination, by the Acting Bacteriologist, Dr. William G. Bissell, demonstrated in water drawn from the mains, the presence of the essential cause of typhoid fever, the *Bacillus typhosus*. Previous to this discovery, I was assured by a number of prominent physicians that they knew of no diversity of opinion among the medical profession, that the epidemic was due directly and wholly to the contamination of the city water supply by the city sewage.

The short duration of the epidemic was probably due to the peculiar construction of the water works system, which causes a rapid circulation, and thus the uninfected water taken from "the crib" in midstream soon swept the mains free from the fatal bacilli.

As incidentally connected with this case, it may be mentioned that during the prevalence of the epidemic in Buffalo, grave apprehensions of danger seized the minds of the inhabitants of some of the villages which derive their water supply from the lower part of the river, such as the villages of Niagara Falls and Suspension Bridge, and threats were made of legal processes to restrain the city of Buffalo from contaminating their water supply. The epidemic having ceased in Buffalo, the *modus vivendi* has no doubt been resumed, to continue until the next explosion, when it will be too late to apply a remedy for that time.

Has not the sad experience of our sister city a most impressive lesson for the citizens of Rochester? It is true that it may not have taught us any new facts in sanitary science, but it certainly has placed a tremendous emphasis on the importance of putting what we do know into daily practice. Who can compute the cost of a thousand cases of such illness? What is the pecuniary cost in loss of valuable time, and in the expense of nursing and medical attendance? Who can estimate the physical suffering, the mental distress of those afflicted, each the center of a sympathizing circle, beside the loss of valuable lives?

You may say that Buffalo will never repeat this irreparable blunder, and in Rochester it is impossible. But let us remember that the invisible causes of contagious diseases are wonderfully transportable, and have free passes on all lines of travel, and so may find access to our water-supply by other means than by pumping in city sewage. We should remember, also, that there are other pathogenic bacilli besides those of typhoid fever, with whose life histories and nature we should be thoroughly acquainted, in order that we may be forearmed.

With the facts of the Buffalo epidemic clearly before us, can we say that the apprehensions of the lower villages were wholly groundless, as they thought of the entire sewage from a city of 300,000 people being poured into the water from which they must drink? Consider the contamination which many large cities are daily pouring into Lake Erie and Lake Ontario, and ask yourself if such facts can contribute to the peace of mind of any thoughtful person who draws his supply of water from either of these lakes. We may, I think, congratulate ourselves that our enlarged supply is to be obtained from Hemlock Lake rather than from Lake Ontario.

The trend and drift of these suggestions may be fairly considered selfish, though in a broad sense. They are in the direction of self-protection and self-preservation. But it may be well to remind ourselves that our city is not an island in the ocean, it has a vicinage and neighbors near and remote. They have rights as well as we, and on these rights we may not trespass. Has a city any more right than a private citizen to render itself a nuisance by discharging its waste upon their property, and rendering odious, if not dangerous, the air they must breathe and the water they must drink? Is it a premature question to ask if the time has not almost come when cities shall no longer convert the natural waterways into sewers, and the lakes into reservoirs for their sewage? Methods of sewage disposal and disinfection have been already so far perfected that in my opinion, at no distant day, compulsory destruction of all offensive and dangerous waste material, of whatsoever kind, may be legally enforced without serious expense or inconvenience, Again, are we quite rational and sensible in the relative estimate we place upon our most cherished possessions? Do we not strangely, insanely under-rate health and life and over-rate greatly the mere things which possess absolutely no value at all apart from life and health? For example, look at our splendid and costly equipment for the protection of our property. See these big fellows who look so handsome in blue and gold. We keep an army of them, 162 in number. We take great comfort in them. With what a sense of sweet security we fall asleep as we hear the familiar though unmusical signal of our guardian angels prowling around! With what municipal pride do we review them on the Fourth of July and other gala days! And we pay for them, more or less cheerfully, $161,664 a year. Then again take a glance at our magnificent fire department,—its luxurious houses, its prancing horses, its glittering engines, trucks, and hose-carts. Then, too, look at the intricate electric net-work which spreads over the city like a metallic veil, and brings us all in touch with the great bell in the city hall tower, which startles us with its harsh clang whenever fire touches the humblest hovel. All this costs us $187,826 a year. Do we say, what is the use of all this, we have had no serious conflagrations for years? No, we do not reason that way. We talk about protection and prevention in these matters. But the menace of infectious diseases is as imminent as that of fire. And surely a man's life is of more value than the house he lives in, be it hovel or palace. Yet when the fire of fever breaks out there is no startling alarm from the great bell, no smoke and thunder of flashing engines, or sudden gathering of crowds in the street. No, the poor victim is left to fight his battle as best he can, with friends, nurse and doctor, as silent and well nigh helpless witnesses of the struggle.

We should be ready to meet and exterminate any epidemic which may suddenly make its appearance, as we fight fire. Where is our trained sanitary police? Where our equipment of hospitals and disinfecting appliances and supplies kept in readiness for instant use, before the pestilence has time to smite down a thousand unprotected victims? It is wise in time of peace to place ourselves on a war-footing against the attacks of epidemics, whose tactics are now, thanks to brave and laborious scientists, not wholly mysterious to us, and thus promote and preserve our peace of mind, and safety of life and health. Such an investment of money would be a profitable one. No stronger element of prosperity can a city possess, or greater attractions for good citizens can it offer, than a low death rate and a high health grade.

Lastly, the experience of our neighboring city once more shows with what unthinking complacency we commit ourselves supinely every day to the discretion and unproved competency of the man at the throttle lever or the pilot's wheel. The opening of a valve in a moment of thoughtlessness let in an army, as the hosts of Cyrus who entered Babylon by way of the bed of the river Euphrates. In the light of such an experience, how clear it is that the safety of this city requires that the purity of Hemlock Lake should be guarded as if it were a mine of diamonds. If the present means and methods employed for its protection are good, let them be made better, and progressively better, as sanitary science gives us more and more intelligence and light. Nothing less than unrelaxing vigilance, the certified intelligence, and fidelity of every officer charged with the administration of this trust, can give the people of this city that sense of safety and security which the city owes them.

Remarks were made by Dr. M. A. Veeder, Mr. J. Y. McClintock, Dr. George W. Goler, Major William Streeter and the President.

The third paper of the evening was presented, as follows:

THE PITCH LAKE OF TRINIDAD.

By Adelbert Cronise.

CONTENTS.

The Island.

The Pitch Lake of Trinidad is not only a great natural curiosity, but as the source of our "Trinidad Asphalt" it is a place of scientific and commercial interest. A run of sixteen days from New York, on a course considerably east of south, takes us to the island of Trinidad, the most southerly of that group of the West Indies which we call the Windward Islands, lying within eleven degrees of the equator and in the longitude of the eastern part of Nova Scotia, or fifteen east from

Washington. The island is separated from South America by the Gulf of Paria ; and LaBrea, the point at which we land to reach the Pitch Lake, is on the west side of the island opposite the easterly coast of Venezuela. Much of the island is wooded and mountainous, the highest of the peaks rising to a height of about three thousand feet.

The Lake.

From LaBrea a walk of a mile over a made asphalt road through jungle and forest leads up to the lake, which is a hundred and thirty-eight feet above the sea-level, the land sloping up to it from three sides. The lake is of somewhat irregular shape, approximately round, and has an area of 109 acres as determined by the government survey. The surface of the lake is a number of feet higher than the level of the ground immediately about it, having been lifted by the pressure from below. (*See plate 13.*)

The material of the lake is solid to a depth of several feet, except in a few spots near the centre where it remains in a soft condition, but usually not hot or boiling as often described. Consul Pierce states that in the hottest part of the day he has seen a man walk into this softest part without harm, that it only came to the calves of his legs, and that it was pliable as soft putty but did not stick. Also that in the cool of the morning he has seen a man walk over the softest spot without sinking deeper than his foot. As this part is not always the same it is possible that at times it may have been, as it has been described, a cauldron of boiling pitch.

Although approximately level, being a few inches highest in the centre, the surface of the lake is far from smooth, being marked by many fissures two or three feet in width and slightly depressed spots, all of which are filled with rain water. In going about one has to pick his way among the larger puddles and jump many of the small connecting streams. Each of the hundreds of irregular portions separated by this network of fissures is claimed to have a slow revolving motion upon a horizontal axis at right angles to a line from the centre of the lake, the motion of the surface being from the centre toward the circumference. Such a motion would account for the roots, leaves and bits of wood of comparatively recent vegetation which are constantly being brought to the surface. The motion is claimed to be caused by the great daily change in temperature, often from 60° at night to 140° in the day, or 80° change, and an unequal upward motion of the mass below, increasing toward the centre of the lake.

Scattered about the surface of the lake are about thirty small patches of shallow earth covered with bushes and small trees. Mr. McCarthy, the local manager of the Trinidad Asphalt Company, states that he removed the layer of earth forming one of these islands and that the pitch below then rose to the general level of the lake.

The Pitch Lake has been the subject of many exaggerations, misrepresentations and romances, not only by mere travelers but by writers of supposed authority. Two of our leading encyclopedias state that its circumference is about three miles, which would give it four times its actual area. In a paper recently read before the American Institute of Mining Engineers the lake is stated to be three miles from the sea, while in fact it is but one, and both elevation and size are incorrectly stated. An official history of the English Exposition of 1851 states that the Pitch Lake is on the highest land in the island, which is 3,100 feet, while the actual elevation of the lake is but 138 feet. The same authority states that "there is an active submarine volcano near the coast," while another writer says that there is "a submarine volcano which at times makes a noise like thunder and emits naphtha and petroleum." The simple truth is that in one spot near the shore a little oil and gas rise to the surface of the sea. The "noise like thunder" probably refers to the report from the bursting of the bubbles of gas. The few small patches of vegetation upon the lake have been exaggerated to resemble the Thousand Islands of the St. Lawrence.

The Pitch.

The asphaltum or "pitch" at the surface is of a brownish-black color and hard to the touch. Even in the hot sun of the tropics it is brittle, except at the centre, so that a pick struck into it will break out pieces of several cubic feet in size. Although brittle it is porous and light so that one man lifts the large pieces into the carts without assistance. After digging down to a depth of three or four feet the pitch is found somewhat softer, and elastic rather than brittle, and the pit is then left to fill up again. Within a day or two the pressure from below will have raised the elastic bottom of the pit to the level of the surrounding surface, but as it is hardened by exposure to the air this lifting is checked and the surface remains nearly level. In this way probably over half a million tons have been taken out within a small area near the margin of the lake without lowering its level.

The statements of the amount of pitch in the lake, varying from two to four million tons, while mere guesses, seem to me to be under

Cronise—Pitch Lake of Trinidad.

the truth. If half a million tons has been taken out from a small area without appreciably lowering the surface it is impossible to make an estimate of any value as to the extent of the supply.

The origin of this never failing supply of pitch is not certainly known. The theories of vegetable, animal, mineral and volcanic origin have been much discussed. The nearest that can be said is that it is from the decomposition of organic matter.

The term "pitch," probably from the Greek *πιτυς*, the pine tree, was first applied to the residuum of boiled tar, or vegetable pitch. It is now applied also to some of those mineral substances of an oily or resinous nature known as bitumens, composed chiefly of carbon and hydrogen, and varying from naphtha, the most volatile, to pit-coal the most solid. The relation of the pitch of Trinidad, or asphaltum, to the most important of the series is as follows:

Bitumens.
- Naphtha,
- Petroleum,
- Mineral Tar, or Maltha,
- Elastic Bitumen, or Elaterite,
- Asphaltum,
- Pit Coal.

The bitumens of this series merge into one another so that it is impossible to make clear distinctions.

Exploitation.

The Pitch Lake is the property of the government of Trinidad. Until a few years ago licenses to take asphalt from the lake were given to various parties. These different parties being in competition with one another decided to combine and secure if possible the exclusive right to the lake. As the licenses were not exclusive they were not valuable enough to bring much revenue to the government, and the export duty of twenty cents per ton brought little more. The licensees proposed to the government that if they could have the exclusive right to take asphalt from the lake for a term of years they would guarantee $36,000 a year and pay forty cents a ton for the asphalt taken, and would submit to an export duty of $1.20 a ton. The object in proposing an increased duty was to deter the competition of those who were mining "land asphalt" in the island. The proposition was accepted, The licensees, many of whom were English, organized as "The Trinidad Asphalt Company," a corporation under the laws of New Jersey, with their principal office in Port of Spain, Trinidad. A contract according to the proposed terms was then made by this company with the Trinidad government for twenty-one years. In 1893 the government received a revenue of about $150,000 from the lake.

In addition to the forty cents a ton for the pitch and one dollar twenty cents a ton export duty, the cost of digging the pitch, carting it to the pier at LaBrea and loading it on the steamer is about one dollar fifty cents a ton, or in all three dollars ten cents a ton on board.

The pitch sent to the United States is shipped in bulk as it is dug out from the lake. In the hold of the vessel the pitch softens with the heat and the pieces coalesce into a semi-fluid mass. On reaching the north the mass becomes hard and has to be broken out with picks as when first taken from the lake. In some cases, from unusual heat or a long voyage, the mass became so soft as to list to leeward, and the vessels being unable to right themselves have been wrecked.

The pitch sent to Europe is first refined at LaBrea. When melted all foreign matter, amounting to from 10 to 20 per cent., floats or settles to the bottom, and the pure asphaltum, there known as "pitch épurée", is drawn off and shipped to Europe in barrels.

Most of the Trinidad asphaltum used in this country is bought crude of the Trinidad Asphalt Company by the Warren Chemical and Manufacturing Company and refined at its works at Hunters Point, New York, and then sold to the different paving companies. One of the paving companies, the Barber, has a refinery of its own at Hunters Point and another at Washington.

Asphaltic Pavements.

The Trinidad Lake asphaltum in its natural condition is too brittle for our northern cold. To correct this it is toughened by using with it about 12 per cent. of another bitumen higher in the scale, viz., the residuum of petroleum. This combination is both hard and tough, hard enough not to become soft in the heat of summer and tough enough not to crack in the cold of winter. In this condition it is known as bituminous mastic, or paving cement.

To this mastic or cement fine, sharp sand and powdered carbonate of lime are added, in the proportion of 12 to 16 per cent. mastic, 73 to 67 per cent. sand, and 15 to 17 per cent. carbonate of lime, to make a pavement which will resist wear.

The four conditions from the lake to the pavement are, approximately,—

1. Crude Pitch, { 80 to 90% asphaltum, 20 to 10% foreign matter.
2. Pitch Épurée, or refined asphaltum.
3. Paving Cement, { 88% asphaltum, 12% petroleum residuum.
4. Asphaltic Pavement, { 12 to 16% paving cement, 73 to 67% clean sand, 15 to 17% pulverized carbonate of lime.

This pavement, substantially so made, is the one now laid by most of the American asphalt paving companies, the Warren-Scharf Company and the Barber Company which work in most parts of the country, and the Rochester Vulcanite and other companies which operate locally in their several cities or sections. The pavement originally laid by the Rochester Vulcanite Company was a compound of Trinidad asphalt, sulphur, lime, cement, sand, stone dust and distillate of coal tar, but the pavement now laid by this company is substantially the same as that first described above.

Trinidad Land Asphalt.

Besides the "lake asphalt" from Trinidad the island furnishes what is known as "land asphalt," referred to above. This is mined in several places in the island, near LaBrea, and is estimated to cover 3,000 acres. Nearly all of this is covered with earth. Whether it is an old overflow from the lake or comes from the rich bituminous sandstone beneath is a much discussed question. It is harder and contains more impurities or foreign matter than the lake pitch. Even when refined it is said to be inferior to the lake product. Pavements of this land asphalt were recently laid in Denver by the West Indies Asphalt Company, now defunct, under the claim that it was "Trinidad Asphalt" and complied with their contract. The pavements were taken up within the year and the company compelled to pay for repaving with lake asphalt. Those interested in the land asphalt claim for it that it is from the same source and of the same quality when refined as the lake asphalt. Large quantities of the land asphalt are used, as the Trinidad Custom House receipts for the March quarter of 1892 show an export of 10,233 tons, nearly all to the United States, which would indicate about 40,000 tons a year. The customs receipts for the same period indicate an export of lake asphalt of about a hundred thousand tons a year.

Asphalts and Asphaltic Rocks.

There has been much discussion as to the use of the word "asphalt." In this paper it has been used as a synonym for asphaltum. in which sense it is used in the Encyclopedias. The word asphalt is also applied popularly to the mixture of asphaltum, mineral tar and sand used for pavements, and this use is recognized by Webster and The Century in their second definition. In Europe the word asphalt is applied to the bituminous limestones. or asphaltic rocks there used for asphaltic pavements, and foreign writers have assumed to correct our use of the word and say that there are few "asphalt pavements" in America, and that nearly all so-called are an imitation mixture. Their use of it is referred to by the Century Dictionary but is not recognized as a definition, while our use is sustained by nearly all authorities.

The most noted supplies of asphaltum and asphaltic rocks may be arranged in the order of their hardness as follows :—

- Asphaltum,
  - Semi-liquid,
    - Hit, Asiatic Turkey,
    - Coast Counties of California.
  - Solid,
    - Cuba,
    - California,
    - Trinidad "Lake Asphalt,"
    - " "Land Asphalt."

- Asphaltic Rocks,
  - Sandstones,
    - California, Utah and Kentucky,
    - Val-de-Travers, Switzerland.
  - Limestones,
    - Val-de-Travers, Switzerland,
    - Ragusa, Sicily,
    - Vorwohle, Germany,
    - Seyssel, France.

The bitumen used by the Babylonians to cement together the bricks in their public and private buildings is supposed to have been a semi-liquid, similar to the mineral tar, the oil being absorbed by the bricks, leaving a perfect and imperishable cement of asphalt. It is stated by Herodotus (I, 179) that in the walls of Babylon were used bricks baked in kilns, and that hot asphalt was used as cement. From this use as a cement is possibly the derivation of "asphaltum" from *a*, not, and *sphalo*, to cause to slip. The source of this ancient supply was the fountains of Is, (modern Hit, on the right bank of the Euphrates), which still flow abundantly.

The California asphalt is of two kinds, the semi-liquid, similar to that used by the Babylonians, more like a mineral tar than a true asphalt, and a solid asphalt which is used in road building without mixing with other substances. About forty thousand tons a year of this California asphalt is now used, but the cost of transportation by land prevents its use here in the east as it can be brought much cheaper from Trinidad or Europe. In Kansas City the California Asphalt Company of San Francisco is about to establish a plant and introduce its use in that section.

The hardest in the series are the bituminous sandstones of California, Utah and Kentucky and the bituminous limestones or asphaltic rocks of Switzerland, Sicily, Germany and France. The rock from Val-de-Travers in the Canton of Neufchatel contains 20 per cent of asphalt, that from Ragusa, Sicily, 12 per cent. and the Vorwohle rock 11 per cent. Those from Seyssel, France, are the hardest and contain but 10 per cent. of asphalt to 90 per cent. of carbonate of lime. These rocks are of a brown color, and slightly malleable, and break with an irregular fracture. They are reduced by grinding or roasting. Those richest in asphalt form a good pavement without mixture. To the hardest a small percentage of mineral tar is added to produce a paving compound, or the German rock is mixed with the softer Sicilian rock in the proportion of one to three, as is done by the Rock Asphalt Pavement Company of this city.

The world's supply of asphalt is not limited to the supplies named, but quantities of it are found in Canada, Venezuela, Peru, Mexico, Argentina, Turkey, Syria and other countries. However it is not probable that any large supply will be found which is at the same time so pure, so easily taken out and so near a shipping point as that of the Pitch Lake.

The paper was illustrated by specimens of the Trinidad and other asphaltums, and the commercial products.

Remarks upon the paper of Mr. Cronise were made by Professor A. L. Baker, Mr. Elon Huntington, Professor S. A. Lattimore and several other members.

Professor A. L. Arey drew the attention of the Academy to a locality in Seneca Park, on the river bank, which had been formerly regarded by the late Mr. George Harris as an Indian quarry and shop site for the manufacture of flint implements, and stated that this was an out-crop of the chert-bearing limestone of the Upper Clinton.

May 28, 1894.

STATED MEETING.

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

Thirty persons present.

The following paper was read :

NOTES ON OPHIDIANS OF THE SOUTHERN STATES.

By F. W. Warner.

A person accustomed to out door life in the South must become more or less familiar with the southern serpents. The warm sun, the softer atmosphere and the rank vegetation are peculiarly favorable to their existence. The sinuous lines of the serpents are seen in the streams, they are continually crossing one's path, and the planter as he is turning over the soil is constantly dislodging them from their holes. The number of the serpents which are encountered is not so much a matter of surprise as their great variety. They are large and small, long and short, venomous and innocuous. There are ground snakes, tree snakes, water snakes, sand snakes and burrowing snakes. The serpents encountered are frequently new species, which those who are best informed in snake lore can at once neither name nor classify. This fact is not so strange when it is known that there are 1,800 species of serpents described and named.

All of the ophidians are not necessarily our natural enemies. Some of them seem to be desirous of living on friendly terms with man, and are even capable of being domesticated ; others are unfriendly and aggressive, but the great mass of them desire to keep away from human habitations and simply want to be let alone.

We encounter these limbless denizens of meadow and forest in all colors of skin. Some are repulsive looking, with loose and flabby dress, coarse, dull, or black, with light colored lining and reveals. Some prefer solid colors and wear a jacket of brilliant red, green or yellow, with a vest of lighter hues. Others dress in stripes with a striking effect of dark and light in strong contrast. Some express a taste for plaids, and wear a handsome plaid coat with a yellow waistcoat and red tie. Again others are dressed in Scotch plaids with a singularly harmonious shading of red, green and brown. Then there is a great variety of odd figures worked into the ophidian wardrobe, polka dots, diamonds, rings, ovals, and various nondescript figures.

These creatures not only show great variety of taste in their garments but they are most extravagant in dressing. They will wear a brand new garment but a season when they cast it away on some brush pile and don an entire new suit. '

An important and unusual peculiarity in the ophidian race is that the female is larger and stronger than the male. Two large rattlesnakes were killed on the same spot on a plantation in Louisiana. They had evidently attained their growth as they were both over nine feet in length. The female was found to be five inches longer than the male. In many birds and quadrupeds we find a great distinction in dress in favor of the male. But in ophidian society the female is dressed in brighter colors and a handsomer wardrobe.

Serpents differ widely in their size, proportions, colors and other physical characters, but they differ still more in their habits, temper and instincts. The study of ophidians from this point of view would be most interesting and instructive.

There are some serpents that are always annoyed and irritated at the presence of man. They are always ready for a fight and begin at once to hiss and snap in a vicious and threatening manner. If one finds himself in the presence of one of these creatures it is difficult to part company without a fight. The water moccasin (*Toxicophis picivorus*) is of this class; it is unfriendly and always ready for a fight. The moccasin lies along the margin of a stream or catches upon driftwood and lazily watches for his prey, which consists of fish and frogs. They sometimes grow to enormous size, being short and thick. I once dispatched one of these monsters which would measure fully fifteen inches in circumference.

The Pit viper or common rattler, is found in all the Southern States, and is the most dreaded of all serpents. A gang of negroes will leave their work and run to a place of safety when the presence of a rattlesnake is suspected. The rattler will not attack a man unless disturbed or provoked to a fight and even will run away if given a chance. He will always give due notice of his presence by springing his rattle and also by an unpleasant odor.

The bull snake, which I have been unable to classify, is a long, heavy, muscular fellow, frequently growing to a length of seven or eight feet. He is of a reddish brown color with faint stripes and has a large oval head. He makes a noise like the bellowing of a bull. This snake is very shy and is seldom seen or captured. I have never encountered a specimen except in Georgia. The living one I examined was nearly six feet long.

There are serpents which do not resent the intrusion of man and show a desire to be on friendly terms. It is known that the rat snake of India, (*Ptyas mucosus*,) although by nature ill tempered and treacherous, is frequently domesticated and makes himself extremely valuable in catching rats, mice and other vermin. While residing in London I made friends at the Zoological Gardens with a splendid specimen of the rat catcher, eight feet in length. He would lay his head upon my arm while I stroked his head and neck. He showed his pleasure by shutting his eyes and gently raising his head to increase the pressure of my hand and evidently enjoyed the caresses as much as the drug store tom cat when receiving the same attention.

From my observation I think the chain snake, or king snake, of the south, (*Ophibolus getulus*,) is capable of being domesticated in the same manner as the *Ptyas mucosus*. I succeeding in attracting a king snake to my engine house and for more than a year he kept away all other serpents as well as the rats and mice which before had been extremely troublesome. The pretty creature would show himself quite frequently and take the food we placed for him, but we never succeeded in handling him. Many mills and even private houses have these snakes domesticated and they are as harmless as a cat, but more vigilant and useful. The creature is a very dude among snakes. His garment is in broad stripe of brilliant red, bronze and gold, worn diagonally across his back like the long twisted links of a chain. His collar is white and he has a red tie. No one in the south will ever kill or wound a king snake and the negroes hold him as exempt from harm as a sailor does an albatross. The king snake does not take his name simply from his royal robes but he is the veritable king of serpents. He will attack and kill the largest black snake, pilot or rattler with perfect confidence and win an easy victory. He will seize his enemy by the neck and coil rapidly about his body. He causes death probably by stretching himself and parting the vertebræ of his victim.

There is a wide difference in the courage and instincts of serpents. Some will resent the least interference and boldly advance to attack, while others are cowardly. The southern black adder is a large puffy braggart, but is really a coward and has the instinct of the opossum ; in the presence of danger he feigns death but when the coast is clear he will open his eyes and make off to a place of safety.

Papers read 1893–1894, but not printed.

ADMINISTRATIVE PROCEEDINGS.

OFFICERS, 1894.

PRESIDENT,

HERMAN LEROY FAIRCHILD, *University of Rochester.*

VICE-PRESIDENTS,

J. M. DAVISON, M. L. MALLORY.

SECRETARY,

ARTHUR LATHAM BAKER, *University of Rochester.*

CORRESPONDING SECRETARY,

CHARLES WRIGHT DODGE, *University of Rochester.*

TREASURER,

F. W. WARNER, *203 Granite Bldg., Main Street.*

LIBRARIAN,

FLORENCE BECKWITH.

COUNCILLORS,

J. L. ROSEBOOM, WILLIAM STREETER.
HENRY A. WARD. MARY E. MACAULEY,
J. EUGENE WHITNEY, J. Y. MCCLINTOCK.

CURATORS,

J. B. FULLER, in Botany.
SHELLEY G. CRUMP, in Conchology.
CHARLES W. DODGE, in Biology.
ALBERT L. AREY, in Geology.