TRANSACTIONS

OF THE

NEW YORK ACADEMY OF SCIENCES.

TRANSACTIONS

OF THE

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VOLUME V.

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1885–1886.

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1886.

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TRANSACTIONS

OF THE

NEW YORK ACADEMY OF SCIENCES.

October 5th, 1885.

REGULAR BUSINESS MEETING.

Vice-President, Dr. O. P. HUBBARD, in the chair.

Fifty-six persons present.

PROF. D. S. MARTIN, Chairman of the Committee of Publication, reported that during the summer the "Annals" for the preceding year (1884–5) were completed. Also that the volume of "Transactions" for 1883–4, edited by Dr. Julien, was almost ready for the press. He also reported that the Secretary had offered to assume the editorship of the "Transactions" for the current year, and that Dr. Britton offered to edit the volume for past year (1884–5).

On motion of VICE-PRES. TROWBRIDGE, it was voted to authorize the Council to publish the "Transactions" for the present year and the past year, if the condition of the treasury justified the expense.

The LIBRARIAN reported the following:

ACCESSIONS TO THE LIBRARY,

received during the summer, 1885.

Great Britain and Ireland.

The Royal Dublin Society.
Scientific Proceedings, Vol. IV. (N. S.), Pts. 5 and 6. Dublin, 1884–85.
Scientific Transactions, Vols. IV., V., VI. Dublin, 1884–1885.

The Royal Cornwall Polytech. Society.
52d Ann. Rep., 1884. Falmouth, 1884.

The Hertfordshire Natur. Hist. Soc. and Field Club.
Transactions, Vol. II., Parts 7, 8, and 9. London, Watford, Hertford, 1883–84.
Annual Report, 1882. Hertford, 1884.
List of Members, Feb., 1884. Hertford, 1884.

The Royal Micros. Society.
Journal, Series II., Vol. V., Parts 2 and 3. April and June, 1885. London, 1885.

The Linnean Society of London. List, 1884–85.
Journ. of Zoology, Vol. , Nos. 103–108.
Journ. of Botany, Vol. XXI., Nos. 134–137. London.

The Zoological Society of London.
Proc., 1885. Part I. London, 1885.
Proc. of Scientific Meetings, Part IV. London, 1884.

The Royal Society of London.
Proc., Vol. XXXVII., Nos. 232–237, 1884–85. London, 1884–85.

British Assoc. Advanc. Science.
Report, 1884, Montreal. London, 1885.

France.

Le Muséum d'Histoire Naturelle.
Nouv. Arch., 2e Séries, T. 6e. Paris, 1884.

La Soc. de Thérapeutique.
Bull. et Mém., 1884, 1e Ser., Tomes I., II., IV., V. Paris, 1868–75.
Bull. et Mém., 2e Sér., Tomes I.–VI., X., XI. Paris, 1875–85.
Bull. et Mém., 16e Année, No. 12, 1885. Paris, 1885.

La Soc. Linnéenne de Bordeaux.
Actes, Vol. XXXVII., 4e Sér., T. VII. Bordeaux, 1883.
La Soc. Entomologique de France.
Bulletin, pp. LXXXIX.-CXXXVI. Paris, 1885.
L'Institut de France.
Notice sur les Lois de Frottement. Paris, 1884.
La Soc. des Sciences Hist. et Natur. de l'Yonne.
Bulletin, Année 1884, 38e Vol. Auxerre, 1885.

Austro-Hungary.

Der Naturforschende Verein in Brünn.
Verhandlungen, XXII. Band, Heft 1–2, 1883. Brünn, 1884.
Bericht der Meteor. Commis., 1882. Brünn, 1884.
Kurze Erläuterung zur geol. Karte der Umgebung von Brünn. Brünn, 1884.
Königl. böhmische Gesell. d. Wissen. in Prag.
Sitzungberichte, 1882–3–4. Prague, 1884.
Abhandlungen, VI. Folge, 12 Band, 1883-84. Prague, 1884.
Jahresbericht, 1882–3–4. Prague, 1884.
Geschichte, I., Kalonsek, 1884. Prague, 1884.
Bericht, I., Studnicka, 1884. Prague, 1884.
Verzeichniss der Mitglieder. Prague, 1884.
Generalregister, Wegner, 1884. Prague, 1884.
Die Kaiser.-König. Geogr. Gesell. in Wien.
Mittheilung, XXVII. Band, 1884. Vienna, 1884.
Die Kaiser.-König. Geol. Reichsanstalt.
Jahrbuch, XXXV. Band, 1 Heft, 1885. Vienna, 1885.
Verhandlungen, Nos. 1–7, Plates 5. Vienna, 1885.
Die Kaiser.-König. Zool.-botanische Gesell. in Wien.
Personen-, Ort- und Sach-Register. Vienna, 1884.
Verhandlungen, 1884, XXXIV. Band. Vienna, 1885.

Germany.

Die Deutsche Geol. Gesellschaft.
Zeitschrift, XXXVI. Band, 4 Heft. Berlin, 1884; XXXVII. Band, 1 Heft. Berlin, 1885.

Die König. Preus. Akad. der Wissenschaften zu Berlin.
Abhandlungen, 1884. Berlin, 1885.

Der Naturhist. Verein der Preuss. Rheinl. und Westfalens.
Verhandlungen, 5te Folge, 1 Jahrgang, 2te Hälfte. Bonn, 1884.

Der Naturw. Verein zu Bremen.
Abhandlungen, IX. Band, 2 Heft. Bremen, 1885.

Die Naturforsch. Gesell. in Danzig.
Schriften, N. Folge, VI. Band, 2 Heft. Dantzic, 1885.

Die Naturwissen. Gesell. Isis in Dresden.
Festschrift. Dresden, 1885.

Die Kais. Leop.-Carol. Deutsche Akad. d. Naturf.
Leopoldina, 19 Heft, Jahrg. 1883. Halle, 1883.
Nova Acta, Band 45–6. Halle, 1884.

Der Naturwissen. Verein für Sachsen und Thüringen.
Zeitschrift, 4te Folge, 4ter Band, 1 Heft; 2 Heft. Halle a. S., 1885.

Der Offenbacher Verein für Naturkunde.
24ter und 25ter Bericht über die Thätigkeit 1882–84. Offenbach a. M., 1885.

Der Naturw. Verein zu Osnabrück.
6tes Jahresbuch, 1883–84. Osnabrück, 1885.

Der Naturw. Verein in Regensburg.
Corr.-Blatt. Regensburg, 1884.

Der Verein für Vaterländische Naturk. in Würtemberg.
Jahresbuch, 41 Jahrg., 1885. Stuttgart, 1885.

Russia.

La Soc. Imp. des Naturalistes de Moscou.
Bulletin, 1884, Nos. 2–3. Moscow, 1884–85.
Memoirs, VII. Ser., XXXII., 13. Moscow.

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Journal, T. XVII., No. 5. St. Petersburg, 1885.

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Bulletin, T. XXIX., No. 4; T. XXX., No. 1. St. Petersburg, 1884.

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Skrifter, 1882. Throndjem, 1883.
L'Assoc. Géodésique Internationale Commission de la Norvége.
Geodatische arbeiten, Heft IV.
Vandstand observationer, Heft III. Christiania, 1885.

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L'Acad. Royale de Copenhagen.
Bulletin, 1884, No. 3; 1885, No. 1.
Memoirs, Classe des Sciences, Vol. I., No. 11; Vol. II., No. 7. Copenhagen, 1885.

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La Soc. Royale des Sciences de Liège.
Memoirs, T. XII., 2e Se., 1885. Brussels, 1885.

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Bijdragen tot de Dierkunde, Aflevering 10e, 11e. Amsterdam, 1884.
Nederlandsch Tijdschrift voor de Dierkunde, Jahrg. V., Aflev. 1. Amsterdam, 1884.
Het Prov. Utrechtische Genoot. van K. in Wetens.
Verslag van het verhandelde in de algem. verg. 1882–3–4. Utrecht, 1882–84.
Aanteek. van het Verhand. in de Sectie-Vergad., 1882–3. Utrecht, 1883.
De Verdien. der Holland. Geller., etc. Utrecht, 1883.
La Soc. Holland. des Sciences à Haarlem.
Arch. Neerland. des Sci. ex. et nat., T. XIX., 4e–5e livr. Harlem, 1884.

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Die Naturfor. Gesell. in Zurich.
Vierteljahrschrift, 26 Jahrg., Heft 1–4; 27 Jahrg., Heft 1–4; 28 Jahr., Heft 1–4; 29 Jahrg., Heft 1–4. Zurich, 1881–84.

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Bericht über die Thät., 1882–3. St. Gallen, 1884.

Italy.

Rivista Geologica Tulla Brianza. Milan, 1885.
Reale Accademia dei Lincei.
Atti, Anno CCLXXXII., 1884–5, Ser. 4a, Vol. I., Fascs. 13–18. Rome, 1885.
Osservazioni Meteorologiche. Rome, 1885.
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Bollettino, Vol. XV., No. 1, 12, 1884. Rome, 1884.
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Nieuw Guinea en de Papoesche Eil. 1–2 Deel. Batavia, Java, 1884.
Realia Register 1632–1805. Batavia, Java, 1885.
Notulen van de Algemeene en Bestuursvergadernigen. Deel XXIII., 1884, Aflevering 1, 2, 3. Batavia, Java, 1884.
Tijdschrift voor Indische Taal-Landen Volkenkunde. Deel XXIX., Afl. 4, 5, 6; Deel XXX., Afl. 1, 2. Batavia, Java, 1884.

Australia.

The Linnean Soc. of New South Wales.
Proceedings, X., Part 1. Sidney, 1885.
Index perfectus ad Caroli Linnæi species plantarum. Melbourne, 1880.
The Royal Soc. of Queensland.
Proceedings, 1884. Vol. I., Parts II., III., IV. Brisbane, 1885.

Mexico.

El Museo Nacional de Mexico.
Annales, Tomo III., Ent. 7a. Mexico, 1885.

South America.

La Acad. Nacional de Ciencias en Córdoba.
Boletin, T. VII., Entr. 4a. Buenos Ayres, 1885.

Dominion of Canada.

The Canadian Entomologist, XVII., No. 5, May; No. 6, June, 1885. London, Ont., 1885.
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Proc. and Trans., Vol. II., 1884. Montreal, 1885.
Geol. and Natur. Hist. Survey of Canada.
Roll of 34 Maps.
Report and Maps for 1882–4.
Catal. of Canadian Plants, Part II. Montreal, 1884–85.
The Canadian Record of Science, I., No. 2. Montreal, 1884.
McGill College and Univ.
Annual Calendar. Montreal, 1882.
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Proceedings, Third Series, Vol. III., Fasc. No. 2. Toronto, 1885.
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Fifteenth Ann. Rep. Toronto, 1885.

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Johns Hopkins University.
Studies from the Biological Labor., Vol. III., No. 3. Baltimore, 1885.
The Amer. Acad. of Arts and Sciences.
Proceedings, N. S., XII. Boston, 1885.
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Memoirs, Vol. XI., Part II., No. 1. Cambridge, 1885.
Vol. X., No. 3, Embryology of the Ctenophoræ. Cambridge, 1874.
The Museum of Compar. Zoology at Harvard College.
Bulletin, XI., No. 11; XII., No. 1. Cambridge, Mass., 1885.
The American Antiquarian, VII., No. 4, July, 1885. Chicago, 1885.

Des Moines Acad. of Science.
Bulletin, Vol. I., No. 1. Des Moines, Iowa, 1885.
The Library of Cornell University, Vol. I., No. 12. Ithaca, 1885.
The Geol. and Natur. Hist. Survey of Minnesota, Vol. I., Geology. Minneapolis, 1884.
The Natural Science Assoc. of Staten Island.
Proceedings, March 14th, 1885. New Brighton, N. Y., 1885.
The Torrey Botan. Club.
Bulletin, XII., No. 6, June; No. 7, July, 1885. New York, 1885.
The Amer. Chemical Soc.
Journal, VII., No. 5, May; No. 6, June, 1885. New York, 1885.
The Mercantile Library Assoc.
Sixty-fourth Ann. Rep. New York, 1885.
The Amer. Inst. of Mining Engineers.
Transactions, XIII. New York, 1885.
Papers from Trans., 1885, Twelve parts. New York, 1885.
Die Aufgeklärten Mosaischen Archi-Geschichte. Dr. Knoth. Achtes Heft. New York, 1885.
The American Philosopical Society.
Proceedings, Vol. XXII., No. 119. Phila., 1885.
The Acad. of Natur. Science of Phila.
Proceedings, pp. 105–115, 177–208. Phila., 1885.
The Naturalists' Leisure Hour. A. E. Foote, Sept., 1885. Phila., 1885.
Marginal Kames. H. C. Lewis. Phila., 1885.
U. S. Hay-Fever Assoc., 1885. Portland, Me., 1885.
The Brookville Soc. of Nat. Hist.
Bulletin, No. 1. Richmond, Ind., 1885.
The Kansas Acad. of Science.
Trans. of the 16th and 17th Annual Meetings (1883–4), Vol. IX. Topeka, 1885.
U. S. Nation. Museum.
Proceedings, Vol. VIII., Nos. 6 to 11, 1885. Washington, 1885.

Proceedings, Vol. VIII., Nos. 14 to 18. Washington, 1885.
Account of the Progress of Chemistry, 1884. Washington, 1885.
Bureau of Education.
Circulars of Information, No. 2, 1885. Washington, 1885.
Smithsonian Institution.
Catalogue of Scientific and Technological Periodicals. (Smithsonian Miscel. Colls.) H. C. Bolton. Washington, 1885.
Report, 1883. Washington, 1885.
Contrib. to N. Amer. Ethnology. Vol. V. Washington, 1885.
Reports of Observations of the Total Eclipse of the Sun. J. H. C. Coffin. Washington.
U. S. Geol. Survey.
Copper-bearing Rocks of Lake Superior. Irving. Washington, 1885.
Monographs, VI. Fontaine. Washington, 1883.
Monographs, VII. Curtis. Washington, 1884.
Monographs, VIII. Walcott. Washington, 1884.
Mineral Products of the U. S., 1882–3–4. Washington, 1885.

Rev. Henry Griswold Jesup, A.M., Prof. of Natural History in Dartmouth College, was elected a Corresponding Member.

Mr. George F. Kunz read a paper entitled,

ON THE AGATIZED WOODS, AND THE MALACHITE, AZURITE, ETC., FROM ARIZONA.

(Richly illustrated with specimens of all, and with microscopical sections of the fossil woods.)

Undoubtedly one of the greatest of American wonders is the silicified forest in Arizona, known as Chalcedony Park—a park only in name, however, for the giant trees which once grew there have long since fallen and been silicified into agate and jasper. It is situated eight miles south of Corriza, a station on the Atlantic and Pacific Railroad, in Apache County, Arizona, twenty-four miles southeast of Holbrook. This marvellous deposit of probably a million tons of silicified trees covers a thousand acres.

The wood is generally found projecting out of the volcanic ash and lava, which is covered with sandstone to the depth of from twenty to thirty feet, and lies exposed in the gulches and basins where the water has worn away the sandstone.

The silicification probably took place in the following manner: —The trees were overthrown and covered with volcanic ash and tufa; heated silicified waters percolating through the ash, cooled on reaching the tree level, and thus produced conditions favorable to silicification. The variety of colors in the wood is due to oxides of iron and of manganese. It is possible also that the ash was deposited partly in water and thus heated it. There is every indication that the deposit is of considerable depth. Over the entire area the trees lie scattered in all conceivable positions and in fragments of all sizes, sometimes resembling a pile of cart wheels. A tree, twenty feet in length, is often found broken up into as many sections. These multiplied fractures are the result of alternate heat and cold acting on the water collected in the fissures of the tree.

The highest point in the park is some two hundred feet above the surrounding level, and it is here that the buried trees can be seen to the best advantage. Some of them are one hundred and fifty feet long and ten feet in diameter, and lie exposed in all conceivable positions. One section of a tree, which has been broken up, measures eight feet in diameter, ten feet in length, and weighs several tons. The tree was originally about two hundred feet long. Some pieces of the trunks of these trees, which were brought to New York, range from eight inches to three feet in diameter, and from twenty-five to one thousand pounds in weight. The perfect preservation of these trunks is remarkable. The rings are so distinctly visible as to convince even the most incredulous of their organic origin.

The most interesting points in the park have been suggestively named, The Agate or Natural Bridge, Agate Gulch, Amethyst Point, and Fort Jasper.

The most remarkable feature of the park, and a phenomenon perhaps unparalleled, is the Natural Bridge of agatized wood, formed by a tree spanning a cañon forty-five feet in depth, and fifty-five in width. In addition to the span, fully fifty feet of the tree rest on one side, making the tree visible for a length of over one hundred feet. Both ends of the tree are imbedded in the sandstone. It averages three and a half feet in diameter, four feet at the thickest part and three at the smallest. Where the bark does not adhere, the characteristic colors of jasper and agate are to be seen.

Although silicified wood is found in many localities throughout the world, nowhere is it so beautifully colored as at this place.

Here we have every imaginable shade of red, yellow, brown, and green. Sometimes the colors appear in distinct spots, forming a mottled appearance, then again all blend so imperceptibly as to make a much more pleasing and harmonious effect than the decided banding of the agate, where the lines of demarcation between the colors are so distinct as to become obtrusive. The colors above mentioned are often relieved by white, black, and gray, and by transparent spaces of brilliant quartz crystals, or—as sometimes occurs—of amethyst.

Broken sections of the hollow trunks are often lined with amethyst, quartz, and calcite, which add their brilliancy to the endless variety of color.

Beautiful as the wood is to the naked eye, a microscope is needed to reveal its true beauty. Not only does the glass enhance the colors, but it also renders visible the structure, which has been perfectly preserved even to the forms of the minute cells, and is more beautiful now than before the transformation.

Agate-cutting has been carried on as an industry for over three hundred years, in the Oberstein district, in Germany; but little attention has been paid heretofore to the cutting of large masses, because few agates are found over a foot in diameter, and the banding is not such as to offer much inducement. But in the future this material will doubtless be in great demand for interior house decoration, where it can be advantageously used as inlays in wood or stone; for panelling and wainscoting walls; for tiling; and, if desired, for entire floors. Whole table-tops of the largest size could be made from a single section of one of these giant trees, and the design would be Nature's own incomparable handiwork. For mosaic work it would also find a ready use, since the infinite diversity of color would afford an ample field for the imagination of the skilful artisans employed in this industry.

As before stated, the deposit has been estimated at a million tons, but probably not more than a thousand tons would be suitable for the purposes of art, while for finer work only a small part of this would be available. One instance should be noted to show the high estimation in which the wood is held by foreigners. A Russian dealer recently paid $500 for a piece twenty-eight inches in diameter and thirty inches in length, to be cut into table-tops. A large lot was recently sent abroad for cutting, and soon we shall have a new decorative stone which will possess what very few now in use do—the proper hardness.

There is an increasing demand for Scotch jewelry at present, and it would be a great gain if the Scotch designs could be supplemented by American, and the familiar agates and bloodstones now in use be varied with our own beautiful silicified woods.

The subject was discussed by the Chairman and by Prof. Martin, the Secretary, and the author of the paper.

October 12th, 1885.

STATED MEETING.

Vice-President DR. O. P. HUBBARD in the chair.
Fourteen persons present.

The CHAIRMAN exhibited and described

TWO VARIETIES OF THE NEW RED SANDSTONE USED FOR BUILDING IN NEW HAVEN, CONN.

(Abstract.)

The first, from an extensive north and south ridge in East Haven, is composed chiefly of red feldspar and quartz. Sometimes it is a true conglomerate of Archæan pebbles in a feldspathic base, and it lies in massive beds, with a moderate easterly dip.

It has been used as underpinning, platforms, door-sills, and walls of buildings for very many years—nearly two centuries, and side by side with varieties of the Portland stone. It is regarded as by far the best and most permanent, and is now in great favor for fine house-walls and public buildings.

The second specimen is from Corse Hill, Scotland, near Carlisle, England, and is often called "Carlisle stone." It is now used in the outside finish of a new Yale College building. It cuts very easily, and has an agreeable color, but is believed to be not adapted to our climate when exposed to the weather. It is known here, New York, in several buildings. The portico of the Murray Hill Hotel, built of this, seems already to be fading. Some 110,000 cubic feet have been used in the interior of the Capitol at Albany, and the impression is most agreeable.

This rock is made up of exceedingly thin and regular layers, and has a uniform deep red tint. It has a light specific gravity, weighing per cubic foot 141 pounds, while the Medina sandstone of the Capitol weighs 157 pounds, and has a hardness approaching that of granite.

DISCUSSION.

DR. A. H. ELLIOTT, being called upon for an opinion regarding the durability of the imported "Carlisle" stone, said that he could not express a confident opinion, as he had not made a study of the stone, but he regarded it as inferior in durability to varieties of native sandstone.

DR. A. A. JULIEN said there are two varieties of the "Carlisle" stone; one kind from Corse Hill, and another from Balloch Mile. Although it is a porous stone, and probably not adapted to our climate, it had been much used by architects because of its warm color, and the ease with which it could be worked and carved.

DR. ELLIOTT stated that experiments made by the Municipal Gas Co., upon exposed buildings near the North River, had shown that even one coating of boiled linseed oil was a useful preservative of building stone.

The CHAIRMAN remarked that pulverized sandstone mixed with linseed oil had been used for many years for roofs and for covering walls. He gave examples of buildings so treated in New York city and elsewhere. In most cases the stucco had finally cracked, and had been removed.

DR. ELLIOTT observed that one reason for the shorter life of stone-work compared with brick-work is that less care is usually taken with it. Brick surfaces are often painted and repointed. If stone were often oiled, it would certainly, in increased durability, repay many times the cost.

DR. JULIEN said that oil had been considerably used in later years. It lasts five or six years and then requires renewal. It is only a superficial protection. It should be applied to a building as soon as erected. Usually the remedy has not been used until decay and disintegration have reached beyond where the oil penetrates. In some cases it has been found that the back of stone lying in walls of buildings is more decomposed than the face.

MR. GEORGE F. KUNZ gave an account of the meteor, which according to the newspapers, had fallen with terrible effect upon a certain farm in southwestern Pennsylvania, and he also read a letter concerning it from Prof. Tingley, of Alleghany College, Meadeville, Pa.

Saturday, Sept. 26th, 1885, at four o'clock P.M., with the sky unusually clear, a meteor passed over portions of Washington and Alleghany counties, in a southeast direction. The noise which accompanied it was attributed to various causes, as the brightness of the day prevented the meteor from being generally seen. By some persons it was mistaken for a blast or the explosion of a boiler. It was also described as a loud roar or a peal of thunder. One observer says that he heard a queer hissing noise quickly followed by a roaring.

While it is believed that the meteor fell somewhere in that vicinity, no trace of fragments had been discovered or even rumors of the finding of them, although Prof. Tingley had given several days to inquiry and search.

PROF. W. P. TROWBRIDGE described the recent explosion of *Flood Rock*, and the means and methods employed. He also gave a brief account of Gen. Newton's apparatus for boring under water for the purpose of blasting.

DR. ELLIOTT remarked that the explosive chiefly employed, called "rackarock," was ninety-five per cent as effective as dynamite. It was a mixture of dinitro-benzol and chlorate of potash, which formed a detonating compound.

DR. JULIEN gave a brief description of the phosphorescence of marine animals, in anticipation of an experiment which he performed after adjournment.

October 19th, 1885.

STATED MEETING.

Vice-President, DR. O. P. HUBBARD, in the chair.

Thirty-five persons present.

DR. N. L. BRITTON read an extract from the *New York Times*, copied from the *Worcester* (Mass.) *Spy* of Oct. 14th, relating to the discovery of a human skull near the spot, in Shrewsbury, Mass., where mastodon remains were found a year ago. The article stated that this was the first discovery of mastodon remains east of the Hudson River. DR. BRITTON referred to the discovery of a large portion of a mastodon's tusk in a cellar excavation in Morrisania, New York City, three years ago. He, at that time, exhibited fragments to the Academy, and the matter was noted in the TRANSACTIONS and in the *School of Mines Quarterly*.

PROF. D. S. MARTIN stated that some fifteen or twenty years ago a mastodon skeleton was exhumed in excavating for the Ridgewood, L. I., reservoirs.

The CHAIRMAN said that, in his knowledge, only three other localities east of the Hudson had supplied these fossils. They were Bristol, Conn.; Mt. Holly, Vt.; and a place in Nova Scotia. Agassiz had teeth from the Mt. Holly specimen. It was a question to what degree the Hudson might have been a barrier to the migration eastward of these animals.

The paper announced for the evening was read by DR. A. A. JULIEN.

ON A PHOSPHORESCENT FLAGELLATE INFUSORIAN, PROBABLY A NEW SPECIES OF NOCTILUCA, FROM THE SURF AT OCEAN BEACH, N. J.

(Illustrated with an exhibition of the phosphorescence, and of preparations under the microscope.)

In this paper DR. JULIEN described the remarkable brilliancy of the sea as observed along the New Jersey coast for several evenings in the early part of this month. He found a direct relation between the temperature of the water and the degree of luminosity of the same, and referred the phenomenon to the shoreward movement of surface bands of warm water from the Gulf Stream. Various forms of acalephs and ascidians (*Salpa*) were found in the water, but although many of these were luminous, none of them could account for the general and striking milky-white glow of the sea, which presented a most remarkable aspect, and on the night when it was most marked, allowed a person to read print while standing on the beach.

Upon making a microscopic examination of the water, he found it abounded with a minute organism which he regarded as the source of the diffused luminosity of the sea. However, he had not observed phosphorescence in the individual organism beneath the microscope, after hours of examination. In *Noctiluca* that had been seen. But by pouring alcohol or other fluids into the sea-water, in a dark room, points of light were produced, which gradually faded and disappeared. He also found that the damp sand which had been above the sea-line, even several days, showed phosphorescent points when agitated. These experiments were exhibited to the members after adjournment.

This organism he had thought was probably a new and smaller species of *Noctiluca,* but he now abandoned that idea.

DISCUSSION.

MR. C. F. COX said that the form of the organism, according to DR. JULIEN'S drawing, resembled *bacteria;* but that the flagellum would be a new feature, and that phosphorescence of the *bacteria* would also be a new and very interesting quality. Phosphorescence of the sea was not confined to the open coast. He had observed a diffused luminosity of the water in the Kill von Kull. He thought that the phosphorescence referred to by DR. JULIEN might possibly be of local development, and not connected with warm bands of water from the Gulf Stream. He also suggested that, perhaps, the light referred to might be due to *acalephæ,* and the organisms under discussion accompanied the decay of the former; and even the phosphorescence of the sand might be due to the decaying animal matter.

DR. N. L. BRITTON suggested that the organism might be the zoospores of *acalephæ,* or other recognized animals.

PROF. D. S. MARTIN referred to the extreme abundance of free ascidians (*Salpa Cabotti*), in the waters of the harbor and vicinity in certain years. Especially had this been the case in 1875, when the shores of Coney Island and New Jersey were strewn with them for weeks. DR. TELLKAMPF, our lately deceased member, and the speaker, had made them a subject of study at that time. PROF. MARTIN was disposed to think that the organism in question might be a very young stage of *Salpa,* though how far these latter had been abundant during the present year, he could not say, having been very little at the seaside.

PROF. MARTIN announced the death of RUFUS PRIME, one of the original members of the Lyceum. On motion of DR. ELLIOTT, it was voted to appoint a memorial committee.

The CHAIRMAN appointed as such committee, PROF. MARTIN, DR. ELLIOTT, and MR. GEORGE N. LAWRENCE.

October 26th, 1885.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Nine persons present.

A paper by MR. GEORGE N. LAWRENCE was read by title:

DESCRIPTION OF A NEW SPECIES OF BIRD OF THE GENUS ENGYPTILA, WITH NOTES ON TWO YUCATAN BIRDS.

(Published in the ANNALS, Vol. III., No. 9.)

DR. N. L. BRITTON remarked upon the recent discovery of a new Triassic fossil locality, at Weehawken, N. J., which has yielded many fishes, and a few specimens of *Estheria ovalis*, Emmons. One of the latter was shown, and said to be new to the N. J. Triassic. He also exhibited specimens of a calamitoid plant from the Trias of Doylestown, Pa., sent by Mr. E. J. Pond. This is probably identical with *Schizoneura laticostata*, Fontaine (*Equisetum laticostatum*, Rogers). He also showed casts of a bivalve shell from Phœnixville, Pa., resembling *Unio*, and probably an undescribed species. This is one of the few cases of the occurrence of mollusks in the eastern Trias of America.

The PRESIDENT stated that he has personal information from PROF. MARSH that at last there had been found a skeleton of one of the *Dinosaurs* which had left their footprints in the brownstone of the Connecticut valley. The skeleton was of small size, indicating a length of the reptile of perhaps four or five feet. The posterior part of the skeleton was quite well preserved.

During a discussion which ensued, the following remarks were made by PRESIDENT NEWBERRY.

ON THE AMERICAN TRIAS.

The Trias of all the eastern half of the continent represents only the uppermost portion of the series, the equivalent of the Rhætic beds of Germany. The Muschelkalk and the Bunter are wanting. This is clearly shown by the fossil plants obtained by Emmons and Fontaine from the Trias of North Carolina and Virginia, and by the speaker from New Jersey and Connecticut. The former have recently been described in one of the Monographs of the U. S. Geological Survey. No descriptions of the latter have yet been published; but they consist chiefly of Cycads and Ferns, of which the two most common are *Otozamites latior*, Saporta, the Rhætic form of *O. brevifolius;* and a *Clathropteris* which is scarcely distinguishable from *C. platyphylla,* which is common to the Rhætic and Lias.

The fishes so abundant in our Trias, *Ischypterus* and *Catopterus,* have never been found in the old world, and therefore throw no light on the question. But their affinities are more with the Mesozoic fishes (Jurassic and Cretaceous) than with *Palæoniscus,* etc., of the Permian. Much rarer fishes have been recently obtained by the speaker from the Connecticut Trias—*Diplurus* and *Ptycholepis*—which, though new, represent groups confined to the Jura of the old world.

Dr. White has obtained fossils from Idaho which apparently represent the Muschelkalk. And possibly some of the Trias of Nevada and California may represent the Bunter. But up to the present time no distinctly marked Bunter fossils have been found on this continent. The Ammonites and other mollusks of Humboldt County, Nevada, and the fossil plants of Abiquiu, New Mexico, and Los Bronces, Sonora, are all upper Triassic.

As the Permian proper of northern Europe, represented by the Zechstein and "Copper Schists," has not yet been found in America, it is evident that a considerable hiatus exists in our geological history between the upper Carboniferous and the upper Trias. This may be filled by future discoveries, but at present it must be represented by a blank on our charts.

No distinctly marked Jurassic fossils have yet been found in North America east of the Mississippi, and the well-marked Jura of the Black Hills, Colorado, Utah, etc., overlies the upper Trias beds to which reference has been made, so that the term Jura-trias which has been used by several of our geologists would seem to be unwarranted.

Dr. Britton illustrated by blackboard drawings how a line of limestone outcrops which are found upon the northward shore of the New Jersey Triassic area, in his opinion, would seem to indicate that a portion at least of the floor of the Triassic trough is Palæozoic limestone.

President Newberry drew attention to the probable Archæan age of the crystalline rocks which form the eastward border of the New Jersey and Pennsylvania Triassic areas; they being, according to most local geologists, of the same character as the gneiss and schist of New York Island and Westchester County.

Prof. D. S. Martin remarked that this whole range of crystalline rocks, which he had been disposed to call the Tide-water Gneiss, from the fact that it forms the limit of tide water in all the rivers of the Middle States, from this point southward, has certain marked peculiarities of mineralogical character, which distinguish it strongly from the gneisses of the Northern Laurentian and of the Highlands. In particular, the abundance of sub-silicates and of hydrous silicates is to be noted. In regard to these last, he had often been impressed with the idea of their possible connection with the geological history of the range. The view that he had long inclined to, was similar to that held by Russell for New Jersey, and by Kerr for North Carolina, viz.: that this gneiss-ridge (whatever its original age) had been long submerged, and was elevated at the close of the Triassic period, thus forming a "divide" between the Triassic belts on both sides of it, which are left as border remnants of a far wider area of deposit. In this view, it is an interesting question how far the long submergence of a region of crystalline rocks like this, considering the pressure with which water would be forced to penetrate and permeate it for ages, might result in mineralogical changes, especially in the direction of hydration.

DR. BRITTON regarded the age and nature of these rocks as a most difficult subject to determine, and one which would be more readily settled by study in the field than by laboratory research. He said that the lithology and mineralogy of Fairmount Park is essentially the same as that of Central Park. But at Washington, the rocks contain less feldspar, while northward, in the New Jersey Highlands, they are deficient in mica.

The PRESIDENT reported that the British geologists were now satisfied, after long discussion between Devonian and Mesozoic indications, that the "Elgin sandstones" are of Triassic age. The recent discovery of the head of a Dicynodont reptile, similar, in general, to those previously known from the Trias of South Africa, is regarded as conclusive evidence.

He also briefly described some of the material exhibited at the Geological Congress at Berlin, and the scientific collections in several European cities, particularly those in the London South Kensington Museum.

The LIBRARIAN reported the following

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A Great Trap-Dyke Across S. E. Pennsylvania. H. C. Lewis. Philadelphia, 1885.
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November 2, 1885.

REGULAR BUSINESS MEETING.

The President, Dr. J. S. NEWBERRY, in the chair.

Thirty-nine persons present.

The following persons were elected Resident Members:

MR. WM. H. S. WOOD,
DR. DANIEL DRAPER,
DR. JOHN S. WHITE,
DR. JULIUS SACHS,
MILTON JOSIAH ROBERTS, M.D.

DR. JOHN S. NEWBERRY made an address upon

THE RECENT GEOLOGICAL CONGRESS AT BERLIN, ITS OBJECTS, ITS RESULTS, AND ITS MEN.

November 9, 1885.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Forty-four persons present.

MR. B. B. CHAMBERLIN exhibited an Aquamarine from Manhattanville, New York City. From portions of this mineral two one-carat gems had been cut. One of these was shown. He also exhibited a crystal of Rhodonite from Franklin, N. J.

DR. J. S. NEWBERRY read a paper entitled,

DESCRIPTION OF SOME GIGANTIC PLACODERM FISHES RECENTLY DISCOVERED IN THE DEVONIAN OF OHIO.

(Illustrated with drawings and stereopticon views.)

(Abstract.)

Dinichthys.

The Huron Shale, the upper member of the Devonian system in Ohio, is a black carbonaceous formation, three hundred to four hundred feet in thickness. Though generally barren of fossils—for years yielding nothing but impressions of sea-weeds, which seem to have contributed most of the carbonaceous matter—in 1867 the Rev. Henry Hertzer found in calcareous concretions near the base of the formation, at Delaware, Ohio, some large bones, which were submitted to me, and subsequently described in the Report of the Geological Survey of Ohio, with the name of *Dinichthys Hertzeri*.

A few years later, MR. JAY TERRELL, who resided on the shore of Lake Erie, where it is formed of the Huron Shale, found on the beach some rolled fragments of silicified bones, which were sent to me in Cleveland, and identified as belonging to *Dinichthys*.

Subsequently nearly the entire bony structure of this fish was obtained by Mr. TERRELL from the cliffs along the lake, and the valleys of Black and Vermillion Rivers. These bones were found to represent a distinct species of *Dinichthys*, to which the name of the discoverer was given. And this also was described in the Ohio Geological Report.

Both the fishes mentioned were Placoderms, closely allied in structure to *Coccosteus*, but very much larger, having a length of fifteen or eighteen feet, while *Coccosteus* was only as many inches in length.

Later, the remains of two smaller species of *Dinichthys* were found by Mr. Terrell, to which the names of *D. minor* and *D. corrugatus* were given.

During the last summer, still another species, intermediate in size between those already mentioned, was found by Dr. Gould, of Berea, Ohio, in the cliffs bordering Rocky River, a few miles west of Cleveland. Of this species the cranium is one foot in length, the dorsal shield seven inches in diameter, and nearly circular, the dentition, like that of *D. Terrelli*, consisting of plates with cutting edges, which played on each other like shears; but the premaxillary teeth are broader and flatter than those of the larger species, the mandible narrower and straighter, with a relatively longer cutting edge.

The most interesting feature in this fish, however, consisted in the great size of the eye, which was surrounded by a series of sclerotic plates, like those of *Ichthyosaurus* and the raptorial birds. The circle formed by these plates was about four inches in diameter.

The discovery has latety been made by PROF. VON KOENEN, of Göttingen, Germany, that in *Coccosteus* the eye was also surrounded by a bony ring; and this affords another point of resemblance between these genera.

This lately discovered species of *Dinichthys* was named *D. Gouldii*, in honor of the finder, and it is described in the *Comptes Rendus* of the late Geological Congress at Berlin.

Titanichthys.

About two years since, Mr. Terrell announced to me the discovery, in the Huron Shale, of the cranium and some other bones of a Placoderm fish still more gigantic than *Dinichthys.* While evidently belonging to the same family, it is generically distinct, and I gave it the name of *Titanichthys.*

As in the former genus, the head is triangular in outline, but the largest cranium of *Dinichthys* is about three feet broad across the occiput, while the cranium of *Titanichthys* has a breadth of about four feet.

The cranial surface, as in *Dinichthys,* is granulated or nearly smooth, and is ornamented with a series of incised lines or grooves, which form a distinct and somewhat graceful pattern. The great dorsal shield is two feet in diameter, rounded in outline, and, as in *Dinichthys,* is bordered by quadrangular or trapezoidal post-temporal plates, which are fifteen inches in breadth. The cranium found by Mr. Terrell was associated only with the post-temporal and sub-orbital plates; the latter are paddle-shaped, as in *Dinichthys* and *Coccosteus,* and deeply notched for the eye, which was apparently of large size.

Within the last three months two or three imperfect craniums of *Titanichthys* have been found by Dr. William Clark, of Berea, in the valley of Rocky River; and with these, the dorsal shield and mandibles, before unknown. The latter are about three feet in length, the posterior end spatulate, the anterior turned up like a sled-runner, as in *Dinichthys,* but showing no cutting edge or acute point, so that it may be inferred that the jaw was covered with a horny envelope, as in the turtles.

All the bony plates of *Titanichthys* are apparently thinner than the corresponding parts in *Dinichthys,* though of larger area, and the mandibles, though longer, are much more slender. The general plan of structure, however, seems to have been quite the same, though we yet want the dentition of the upper jaw and the plastron which covered the ventral surface, in order to make a detailed comparison.

The only species yet known was described before the Berlin Geological Congress; and, as the most gigantic fossil fish known, it was given the name of the founder of fossil ichthyology, and was called *Titanichthys Agassizii.*

Diplognathus.

In April, 1878, I read before the Academy descriptions of several new fossil fishes, of which the most interesting was called *Diplognathus mirabilis,* a name chosen to indicate some remarkable features in the structure of the under jaw, the only part then known. This has the general form of that of *Dinichthys*, the posterior end flattened, spatulate, and evidently buried in cartilage, which composed the angular and articular portions of the jaw, as in all the family of the *Dinichthidæ*, including *Coccosteus*, and perhaps of all the Placoderms.

The anterior and exposed extremity of the jaw was provided with a row of conical acute teeth along its upper margin as in *Dinichthys Hertzeri*, but instead of turning up to form a powerful penetrating tooth, it was deflected laterally so that the extremity of the lower jaw was forked, while a row of four strongly recurved teeth was set on either side of the symphysis; the whole forming a sort of rake which would be especially efficient in capturing eel-like fishes, if such served for its food. But as a forked jaw would be liable to split at the symphysis, the lower mandibles were there firmly bound together by a strong ligament, of which the point of insertion is marked by a deep and roughened pit.

Of this remarkable fish a few additional fragments have been found which enable me to complete the mandible, and indicate a fish of larger size than would be inferred from the unique jaw formerly exhibited to the Society, and which served as the basis of the generic description.

November 16, 1885.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Forty persons present.

DR. S. S. FRIEDRICH exhibited several Indian stone ornaments and utensils. Also some fossiliferous pebbles of corniferous limestone from near Sandusky, Ohio.

DR. N. L. BRITTON reported the discovery by Messrs. A. Hollick, W. T. Davis, and himself, of fossil leaves in the cretaceous clays at Kreischerville, Staten Island. The specimens were obtained from a stratum of lignitic clay about eighteen inches in thickness, and included angiosperms and conifers. Several reeds were also collected.

The excavation from which they were taken is about three-fourths of a mile north from Mr. B. Kreischer's fire-brick factory. The section exposed is as follows :

1. Glacial drift, two feet.
2. Pre-glacial yellow drift, six feet.
3. Lignitic fossiliferous clay, eighteen inches.
4. Stiff fire clay, ten feet.
5. Sand.

The occurrence, in abundance, of similar fossils in beds of the same age at South Amboy and Woodbridge, New Jersey, led to the belief that they would be found on Staten Island, which expectation is now fulfilled.

THE SECRETARY stated that the programme of future meetings was complete to March, and that for several subsequent dates scientific papers were already engaged.

PROF. D. S. MARTIN announced the death of MR. THOMAS BLAND, and described his character, life, and scientific work.

The PRESIDENT gave effect to an adopted motion by appointing as a committee to prepare memorial resolutions, PROF. D. S. MARTIN, MR. GEORGE F. KUNZ, and MR. C. VAN BRUNT.

DR. J. B. HOLDER read a paper on

THE RISE AND PROGRESS OF INVERTEBRATE ZOOLOGY.

The literature of invertebrate animals, particularly in the earlier periods of the progress of zoological science, is intimately associated with that of the vertebrate. For a long period, down to the present century, the few invertebrate forms known, or taken notice of by naturalists, were embraced in the same category with vertebrates. Our history, then, must take its rise with and accompany for a season, the vertebrata, those animals embraced in the grand division of which man is the head.

The period preceding the time of Aristotle is generally ignored by naturalists, as producing nothing worthy of being perpetuated in natural history. Doubtless there were those, even at that remote period, who were enabled to see something like a system in nature. Certainly, the glorious record obtained by astronomy, as a science of the greatest antiquity, may reasonably suggest to us that the human mind was not, in remote periods, wholly incapable of appreciating the truths of other branches of natural science. But whatever manifestation there were, certainly no record of consequence has been perpetuated. The immortal Aristotle, the great philosopher of Greece, is, then, accepted as the historian from whom all the recorded data of the science of natural history have emanated. Something over two thousand years ago, this wonderful man was born; to be exact, three hundred and eighty-four years before the Christian era.

The rise of zoology as a study dates from the gift to the world of his famous "Natural History," in which he first sought to define, by the precision of language, those more prominent and comprehensive groups of the animal kingdom, which, being founded in Nature, are exempt from the influence of time and the mutability of learning. Had this extraordinary man left us no other memorial of his talents than his researches in zoology, he would still be looked upon as one of the greatest philosophers of ancient Greece, even in its highest and brightest age. His eloquence and depth of thought are well known, as manifest in voluminous writings.

The death of this great philosopher and father of our science was the decline and death of natural history in the Grecian era. He left no one to follow in his line of study; still less to throw additional light upon realms that his prescient genius had but glanced upon.

From this decline of Grecian learning to the partial revival among the Romans, a long period of darkness prevailed. That the tenets of this great teacher, entertained in the murky atmosphere of ignorance, followed by intervals of thousands of years of comparative darkness and fluctuating intelligence, should have lived until the present time, is the best evidence of their soundness, and the surest test of the author's intellectual pre-eminence.

The zoology of Aristotle in its initial classification being correct, was therefore stable, unalterable, and destined to be perpetuated. The great scholar presented his knowledge forcibly and earnestly, diffusing it at the same time most efficiently by precepts, and admonition to prosecute individual investigation. This knowledge did not advance beyond the recognition of genera and species. More general distinctions were not known. It was the fashion in those days, and long subsequently, to name a form and designate another which resembled it specifically, the "second sort."

Rome and the middle ages did not contribute to the stock of learning. Even Pliny, whose name is so identified with the study of nature, scarcely added a fact of importance. The naturalists of the sixteenth century accomplished little, though they contributed to a more general distribution of the knowledge then known. Systematic zoology was yet in infancy. During the long period extending to the days of Linnæus, little of importance was added. This distinguished zoologist, like Aristotle who preceded him, and Cuvier who came after, stands like one of three magnificent era marks, in the great road of natural science.

The elder Pliny, polished and graceful as a writer, with extended erudition and no inconsiderable ability in description, was content to make use of the writings of those before him. So far, zoological learning did not advance, but as a science suffered a manifest retrograde movement. While Aristotle had boldly expunged from the literature of his day the fabulous stories that had accumulated, Pliny, long afterward, exhibited a weakness that led him to contribute to the popular clamor for extraordinary tales, by reproducing what the noble Grecian had rejected. As Rome possessed in those days one of the most complete menageries ever seen, it is remarkable that it should be left for naturalists of a later day to rectify the abominable errors then extant, and which had existed for 1,400 years.

The Swedish naturalist now took up the thread of knowledge well worn by long continued use, and added, by new stock, essential elements of strength. A glance at the considerable literature of the pre-Linné period reveals a plagiaristic custom that certainly matches the wholesale thieving of the present day; when the text of a Brehm and the zoological art of a Metzler and a Wolf furnishes, by easy process and photo-lithography, many a book on natural science. The old authors during a long period seem to have either used the same engravings or have made close copies, and published them with much the same text in large folios. In some instances the same figures are copied from the coarse woodcuts into well executed copper plate.

While the history of zoology exhibits long periods of inaction, its attendant art shows about the same degree of originality. At one period of time zoological knowledge made gigantic progress in one department and remained stationary in others. At one epoch original research was abandoned, and the technicalities of system and nomenclature alone regarded.

The history of zoology is conveniently viewed in several stated epochs. (1) Its foundation by Aristotle; (2) the time embraced between the revival of learning and that of Linnæus, and (3) from the publication of the *Systema Naturæ* to the time of Cuvier (4). Indeed, we might almost be justified in naming another, though the present is usually judged to be a continuation of the Cuvierian.

One important aspect of the character of Aristotle, whose nobleness of mind was greatly out of proportion to his surroundings, is seen in his bold rejection of the popular tales and fancies that were then received by the mass of his countrymen as religious truth, sanctioned by antiquity, interwoven in their history, and consecrated in their poetry. This noble appreciation of truth, as opposed to fiction and fantastic illustration, stands in wonderful relief when contrasted with the action of some eminent authors who came after him, and who hundreds of years later reclaimed the mass of untruthful and abominable fiction to send it down through later periods, to become the blemish of otherwise creditable books. The establishment of the Alexandrian Museum, including the maintenance of a botanical and zoological garden, was the occasion of the publication of the philosophy of Aristotle as its cornerstone. The Natural History of the philosopher was then being published under the patronage of King Philip, whose son, Alexander, became an illustrious student of the school. The doctrine has taught that all nature was an unbroken chain, the various groups merging insensibly in each other.

After the lapse of four hundred years, the elder Pliny attempted the same illustrious course, but it is the unanimous verdict of science that he was not the genius to add essentially to the glory of his master. His works are numerous, but they are compiled from the archives of previous time, with little that can be regarded as the result of original thought and research. The blessings of all that came after him would have been his, had he eliminated the chaff that had come down to his day, loading great folios and quartos, and serving no possible good. We have seen that Aristotle distinguished only genus and species. Linnæus enlarged upon this, and gave specific names to other groups, of varying weight and value. He recognized classes and orders, but somewhat vaguely, according to the estimate now had of them. He made the distinction of classes, which were natural enough, within the bounds of the vertebrates, as mammalia, birds, reptiles, and fishes; but his class *Vermes* included shells (*Mollusca*), sea-stars, sea-jellies, sea-urchins, corals, etc.

The first attempt to classify animals according to common structural characteristics was made by Linnæus; but it was not until Cuvier had become established as an authority, that anything like great principles of classification were introduced. Cuvier discovered the key at last. His extensive anatomical investigations enabled him to perceive something like the true relation of animals. His favorite idea, as is well known, is that he had discovered plans or types of structure—four well-defined groups, having each its characteristic structure. The *Vertebrata* were certainly well-defined; so the *Mollusca*, a group which yet holds its own as a grand division. His *Articulata* stands in the same relative rank, but under another term, which simply means much the same, *Arthropoda*—both indicating the peculiarity of the class, the jointed or articulated character of the parts that crabs, lobsters, insects, and spiders exhibit in their structure. It is Cuvier's fourth grand division or type that suffers the most change, the *Radiata*—those low creatures that are represented by the sea-stars, sea-urchins, sea-jellies, sea-flowers, corals, and some other low forms. His interpretation of the radiated structure, though clear enough as to many groups, was obscure in some, such as the worms and some of the lowest forms.

Lamarck, Cuvier's contemporary, did not fully acquiesce in the latter's favorite scheme of nature, and published his own plan of the animal kingdom, making the two divisions of vertebrates and invertebrates especially significant. This, of course, is a natural and inevitably permanent initial classification, whatever else may be grouped around it.

Ehrenberg classed animals as those with continuous solid nervous centres, and those having only scattered nervous swellings. This was but another feature of the former, or another way of expressing the same thing; for those forms that have continuous solid nervous centres are the higher animals that need and have a solid, bony skeleton to protect such important nervous centres, whose very integrity depends on their preservation intact, while the scattered nervous swellings are characteristic organs of the invertebrates, whose integrity does not rest with the preservation of the creatures as a whole.

The second period or era of the history of zoology, we have seen, is coincident with the revival of learning in the sixteenth century.

One of the earliest works of this period, or near it, is the *Ortus Sanitatus*, printed in 1485—now an exceedingly rare book.

From the grotesque rudeness of the figures, it would seem to be one of the first to make use of woodcut engravings. Belonius, early in 1500, is an important author. Several editions of his works are extant. Belonius failed to recognize the philosophy of the system of Aristotle, but he produced a satisfactory arrangement of his subjects, considering the time in which he lived, that gained for him a distinguished reputation. In 1554 Rondelitius, the Italian naturalist, distinguished himself by his writings on natural history. And while his work abounds with excellent and accurate, though coarse engravings, and is handsomely embellished, yet it perpetuated the monstrous figures of nondescripts, products of the wildest imaginings. Shells are treated with the fishes, and the subjects of insects and zoophytes follow with little system, but that implied in the succession. Aldrovandus and Gesner now appear in ponderous folios, carrying learning, clothed in all the dignity of large illuminated letter-press, and florid title pages. They are little else but copies of preceding books, or compilations of them. The same figures appear either in wood, or on plates of copper. So little heed was at this time given to system, that Gesner arranged his subjects alphabetically.

Fabius Colonna, a Roman physician, now published two treatises on natural history that were a positive advance in both a literary and scientific sense. A large pretentious folio called Fish Book, in German, without author's name, published in 1575, has tolerable woodcuts of fishes, which are accurately drawn. As was customary for a considerable time, cetaceans are embraced in the category of fishes, and the usual monstrosities are continued. Then follow turtles; and under the title cuttlefishes, the polyps and octopi are treated. Certain forms of marine life seem to have been familiar from a long period. The figures in all of the works illustrating the cephalopods, as far back as they are treated, are correct, and it is thus with most of the *Mollusca*. Though so much of the grotesque seems to be subject for the old authors, the marine invertebrates are always figured correctly; no tendency to caricature being noticed.

"Ferrante Imperato, an apothecary of Naples," says M. De Blainville, "was the first naturalist distinctly to publish, as the result of his proper observations, the animality of corals and madrepores; and he is said to have accompanied the descriptions of the species which fell under his notice, with illustrative figures of considerable accuracy." His *Historia Naturale* appeared in 1599. So little hold did this volume and its very important announcement have upon the minds of scientific men of the day and of subsequent time, that the reproduction of the same views by Peysonnel in 1727, was regarded as the announcement of an entirely fresh subject for the consideration of the savans of the French Academy; and this in the face of the fact that Ferrante's work had been republished in 1672, 73 years after its first edition. A strong opposition to the theory of animality was maintained by the Count Marsigli in 1711. The ignorance of the time was sufficient without the adverse example of this nobleman. There was a tendency to prefer the vegetable theory; and it required little more than the testimony of a titled savan like Marsigli to settle the matter in the minds of the masses. The Count had described the pretty sea objects as blossoms affixed to stalks growing from rocks, or the solid ocean bottom. Who, then, should say nay? Certainly, they have every appearance of flowers, and flowers they were destined to be, in the minds of the people of the period. Peysonnel could not yet prevail over the faith of the unthinking in the infallibility of rank, and, seemingly, the evidence of their own senses; for the resemblances to vegetable forms are unspeakably strong. However, he knew he was right—like Galileo—and so bided his time.

In the works of Tournefort and Ray, the leading naturalists of their age, immediately antecedent to the time when the discoveries leading to modern doctrines took place, the zoophytes, whether calcareous and hard, or horny and flexible, were arranged and described among the sea weeds or algæ. Ray in his *Wisdom of God seen in the Creation*, published in London in 1691, speaking of corals and like forms, says: "Some have a kind of vegetation and resemblance to plants which grow upon the rocks like shrubs." Gesner and Boccone and Shaw regarded them as vegetables, and not entitled to a place among animal life.

The communication of Peysonnel was entrusted to Reaumur. Through a friendly feeling for his friend, the latter omitted the name of the author of the paper, fearing that the Academicians would receive it with expressions of ridicule and distrust. To oppose successfully the convictions of an Italian Count, of zoological fame, and the established belief of the masses, Reaumur thought would be too much for his friend to hope for.

Singularly, Reaumur subsequently read a paper before the Academy, taking opposite grounds to his friend Peysonnel.

The latter's paper was not published, but was embodied with that of Reaumur.

Peysonnel maintained that the blossoms regarded by Marsigli as vegetable productions were "true animals or insects, analogous to the *Actiniæ*, or sea anemones; that the coral was secreted in a fluid form by the inhabitant *Actinia*, and became afterwards fixed, hard, and changed into stone, and that all other stony sea-plants, and even sponges, are the work of different insects, particular to each species of these marine bodies, which labor uniformly according to their nature, and as the Supreme Being has ordered and determined." Peysonnel was the working naturlist, and possessed the spirit of an observer and investigator of the present time rather than the blind superstition and fancy of the picture-book makers of the seventeenth century. Peysonnel was a physician residing at Marseilles. He had the opportunities afforded by contact with the sea-faring men of the coast town. He had seen the zoophytes in their proper sphere; had observed their structure and habits; and finally, had the true inspiration and conviction of the philosopher.

In 1742, Abraham Trembley produced his celebrated treatise on the reproductive powers of the fresh water polyps in the "Philosophical Transactions." This paper brought to mind the statements of Peysonnel, and immediately Reaumur took up the subject with renewed interest. He made personal examinations, and eventually became a stout supporter of the new views. Bernard de Jussieu and Guettard visited the coast of France in the autumn of 1741 and '42, and made extensive examinations of the marine productions. Both soon became satisfied with the new theory. Jussieu enlarged upon the theme, and expressed his opinion that many more objects would be discovered belonging to this class. He examined the tubularias and the flustras, those beautiful forms that are so often gathered on our beaches, and pressed like mosses, which they are mistaken for, finding them analogous to the other forms, pronounced them animal in nature. Indeed, his utterances were now highly prophetic, and his writings both pleasingly popular and executed in the true spirit of science.

Donati—"New Discoveries relating to the History of Coral, by Dr. V. Donati, from the French of Stack, 1750"—made some attempts to continue the exposition of the new views, but his work is regarded of comparatively little consequence.

Peysonnel, yet living, entertained great interest in the subject, and wrote in 1751 a manuscript treatise on Coral and other Marine Productions, which he transmitted to the Royal Society of London. Dr. Watson reviewed this work in the 47th Vol. of "Transactions of the Royal Society" in 1753.

In 1752, John Ellis, an Irish merchant residing in London, but devoted to marine zoology, presented before the Royal Society of London a treatise on the Corallines and Sea Weeds of Great Britain. He states of these forms: "that they differed not less from each other in respect to their form than they did in regard to their texture; and that in many of them this texture was such as seemed to indicate their being more of an animal than vegetable nature." In 1754, he made a more elaborate statement to the Society, and the next year he published his very notable and valuable "Essay towards a Natural History of the Corallines and other Marine Productions of the like kind, commonly found on the coasts of Great Britain and Ireland."

This is a standard work to this day. A copy before me—which, by the way, exhibits on its title the legend: "De Kay to the New York Lyceum of Natural History," a name to be remembered—is in German text, and the plates are excellent copper etchings; being full in species and correct in detail. It is amusing and instructive to revert to these early days in zoological disputation, to see how wisely Ellis and his followers regarded the low forms that have long since his day had their fluctuations in the minds of men as subjects of argument, as to their proper place in Nature. Ellis first supposed that the holes in dry sponges indicated the presence in life of certain animal bodies. He was thoroughly convinced of its animality. Its chemical constituents and its structure were to him conclusive proofs of this fact. "I am persuaded," he writes Linnæus, "the *fibræ intertextæ* of sponges are only the tendons that inclose a gelatinous substance, which is the flesh of the sponge." This is the best answer one can give to-day to a non-professional person who asks, What is a sponge? His subsequent details are still more to the purpose, and show how completely he appreciated the exact nature of these forms.

Ellis came to be considerably incensed at the persistent ignorance that existed in spite of his absolute demonstration. He wrote to Linnæus: "Artful people may puzzle the vulgar, and tell them that the more hairy a man is, and the longer his nails grow he is more of a vegetable than a man who shaves his hair and cuts his nails."

In 1626, Peter Castellano writes, in his "Commentaries on Marine Objects," under the heads *Echini* and *Urticariæ*; the latter embracing the sea-jellies, *Medusæ*, and the few *Actiniæ* then known.

In 1634, a taste for natural history reached England. The *Theatrum Insectorum*, of Mouffet, was the first zoological work published in Great Britain. Mouffet was physician to the Earl of Pembroke, and made the insects his special object of study. The cuts are poor, and the work generally of little account. Rysch, in 1718, *Theatrum Animalium Universale Omnium*, treats of sea-stars, insects, nereids, spiders, crustaceans, illustrated on copper plate. The figures are large and tolerable, but are copies from the great "fish book" of 1575, alluded to *antea*. The term *Urtica* is used as a sort of family name for *Actinia*, evidently from the generally prevailing prickly nature of these forms.

Works in natural history were, up to this time, published in Latin. Such subjects were supposed to be interesting to physicians and ecclesiastical persons only. Subjects of physiology and anatomy, as well as materia medica, were natural accompaniments.

The title pages of some of the old folios are embellished by full-size engravings on copper, surrounded by emblems of high ecclesiastic rank; and these were often of the highest style of art seen in any day. The great expense attending the publication of such works was often borne by high State officials.

In 1658, Edward Topsel, an ecclesiastic of St. Botolph's, in England, published in English the notable books of Gesner, which contained the entire amount of natural history learning of the day, and also Mouffet's work. At this time Count Maurice of Nassau, commanding a Dutch armament which took the Brazilian provinces from the arm of Portugal, took with him the naturalist Marcgrave, then an enthusiastic young student of zoology. Everything that could further the study of those regions was provided. To this munificent patron the world is indebted for the first account of the natural history of tropical America. In Marcgrave's and Boutin's we have the first examples of local *faunæ*, or natural history of particular regions.

On glancing at the progress of zoology so far, we see that a large proportion of the magnificent volumes on zoological learning are little better than compilations, adding little of original matter, and perpetuating the mass of absurdities and fiction so freely accumulated and distributed by Pliny and his contemporaries, and even some credulous writers that followed them. There was in those times so much difference between the man of science and the mass of people, that there was a tendency of the former to magnify and mystify their works, not only in the quantity and quality of text, but by size of type, extravagant initial letters, and magnificent title pages.

England soon followed the example of the Continent. In 1667, the "Pinax" of Dr. Merret appeared, presenting the first treatise on the animals and plants of Great Britain. The work is not of much value. Entomology was now making slow progress in England, while certain new experiments were being made on the Continent. Goedartius and Redi undertook the examination of the metamorphosis of insects, and also their vital functions.

Thus, it is thought, they then established the methods of zoological analysis. Goedart's little volume, published in 1662, exhibits a decided improvement in the entomology of the seventeenth century. The numerous copper plates were faithfully executed, representing the larvæ, pupæ, and perfect forms of a large number of lepidoptera. Many species of other orders were illustrated, and stand to this day worthy objects of study and reference. Thiéry came upon the stage just now with superior work. Swammerdam, who died at an early age, has left us an amount of anatomical lore that stands to-day of equal value to any now extant. All the great truths about the transformation of insects originated with him. Lyonnet, Reaumur, and Bonnet were his disciples, subsequently pursuing his well-beaten path in entomological investigation.

Swammerdam is noted as the "Father of Analysis," as is Aristotle of "Philosophic Generalizations."

The appearance of Ray is regarded by some as coincident with a new era of zoological learning, but others think that his work has less significance than that of Swammerdam, who brought to science a large amount of original observation and research. But for Boerhaave this learning of Swammerdam would have been, perhaps, lost to the world. In 1738, the latter's works were published under the charge of Boerhaave, the great Dutch physician, whose name is a household word with the medical profession.

Martin Lister, secretary to the Royal Society, then recently instituted, so identified himself with Conchology, that he is dubbed the "father" of that science. His first work was, "The Spiders, Shells, and Fossil Echini of Great Britain." All are well described, and systematically arranged. The name of Lister is identified with the establishment of system. Short and expressive specific characters were introduced, a feature that was then uncommon or new.

It is thought that had Lister added generic distinctions and some additional precision to his work, he would have divided with Linnæus his extraordinary reputation. Lister looked at the habits and economy of the insects for indications of their natural arrangement; all of which Linnæus passed over in his zeal for simplification.

In 1685, Lister's great work appeared, embodying his general system, having 1,059 plates or figures of shells, among which are accurately pictured several of the soft parts of the animal. So accurate are the details of this work, it is regarded as of equal value to many of the best to this day.

At this time, natural history began to receive greater attention in Great Britain than in any other part of Europe since the days of Belonius. Neither France nor Italy contributed to the stock. The influence of Bacon, through his philosophical utterances, seems to have inspired the naturalists to greater vigor. The works of Ray and Willughby were little less creditable. There was a strong tendency now to original work. It was the favorite purpose of Willughby to describe only such objects as he had seen, and for the purpose of extending his course, he proposed to go to America. His untimely death at the early age of thirty-seven prevented the consummation of this design. Ray lived to twice the age of Willughby, and had consequently an opportunity to prosecute his work with greater advantages. His reputation is based largely on his "*Historia Insectorum*," published in 1710. His work entitled "Wisdom of God Manifested in His Works" is said to be the first that embodied an attempt to bring the truth of nature into harmony with revealed religion.

Zoology was now cultivated with considerable zeal. Museums were established. The Royal Society became zealous in the good work. A notable collection had become known, including every department of nature. This was the work of one Pettiver. Its value was so well appreciated that it was purchased by Sir Hans Sloane for £4,000. Sloane was the most eminent patron of natural science in Great Britain, holding the high professional station of Court Physician. His wealth and his great love of natural history combined to enable him to collect an extensive library as well as to add to the collections already his. After the organization of the British Museum, which occurred about this time, the collections of Sir Hans Sloane became the nucleus of the Natural History Department, now well known as one of the greatest in the world.

There were numerous persons of more or less wealth that were producing handsome quartos on shells and insects, beautifully illustrated, accurate enough, but of little service for systematic reference. Sloane was rather the dilettante than the lover of science. His well known "Natural History of Jamaica" is valued, but did not embody advanced ideas.

The names of authors of beautiful and more or less valuable treatises in zoology follow in such numbers, that we cannot at this time even mention them by title.

Such was the state of zoological science when Carl von Linné, or, as he is better known, Linnæus, appeared, destined to be one of the grand landmarks on the road of natural science. He created a language that naturalists to this day, the world over, have used as a medium of communication among those who would cultivate the science of natural objects. The publication of the *Systema Naturæ* gave to the study of nature an impetus destined to persist for long periods. Royalty honored him, and the world has fully appreciated his worth. The Linnæan system, so familiar by name, if not always by knowledge, in round terms may be conveniently associated with the commencement of the eighteenth century; beginning an era at that period, though, in truth, the works of Linnæus were produced a few years later. The lustre of Linnæus' genius was somewhat overshadowed by the appearance of Ellis, whose discoveries of the true nature of the lower invertebrates have rendered his fame immortal. The name and memory of John Ellis will be cherished by all lovers of the beautiful sea flowers, the corals, and the innumerable beauties of the ocean depths. Linnæus himself may be allowed to tell us what was the estimate held of his work. Addressing Ellis, he says: "You have enriched our science by laying open a new submarine world to the admirers of nature, and you have taken so lofty a rank in science by your discovery regarding corallines, that no vicissitude in human affairs can obscure your reputation." His work was translated into several languages, and to-day is a rare and valuable book of reference.

About the middle of the eighteenth century, Rumphius, a Dutch naturalist, brought forth a large work on the shells of the East Indies. That is a standard work.

D'Argenville published a treatise on conchology; costly in the extreme, from the perfection of its illustrations.

Regenfuss, of Copenhagen, enriched conchology with a large folio in 1758, which embraced also the *Crustacea*. This is of exceeding rarity. Splendid works by Roesel and Edwards were produced. Trembley, a native of Genoa, made the famous discovery of the reproductive powers of the fresh water polyps—Memoirs, etc., Leyden, 1744.

Just before the publication of the Linnæan System, there appeared several French authors, of whom Reaumur is conspicuous. His work on insects is delightful in text as well as in other features.

Buffon now appears. His name is, probably, more familiar to the people of this country than even that of Linnæus, as his voluminous works are widespread wherever literature is known. In all well-supplied libraries, a set of the numerous volumes of Buffon are quite likely to be seen. All this speaks for the author, in that he produced a history of natural objects that was attractive and readable, at once charming in grace of composition, and sound in knowledge. Eminent as the author stands, yet, had not the scientific aid of Daubenton been his privilege, his works would have failed of the valuable feature that carried true knowledge with it. Buffon's splendid talents of description, wove into golden threads, vivid and fascinating, the more attractive elements of his theme, and captivated the entire reading world. Eloquent and brilliant as he was, his lack of the scientific spirit led him to perpetuate many of the extravagancies and fanciful theories that had been handed down by the great folios of antiquity.

From this time, zoological lore was represented by the two prominent writers Linnæus and Buffon, the former bearing the ensign of true science, and the latter readily mustering the larger class under the banner of a popular and fascinating dilettanteism.

Artedi became an earnest disciple of Linnæus. Sulzer, adopting the Linnæan entomology, wrote on insects. Entomology was now pursued with energy on the continent. The beautiful works, in Dutch, of Sepp, on the "Insects of the Low Countries," reminds one of the magnificent volume of Salviani, devoted to fishes, whose copper plates have never been excelled. At first glance, it may seem singular that such splendid works of art should appear, when, long since their issue, there are extant many others, by important authors, simply vile in the sense of art. But we may reflect that such works as Salviani's and Sepp's were brought out under the patronage of royalty, or wealthy ecclesiastics of the day who were able to employ the great masters, or their pupils, of the time. The best art the world has ever seen in etching and copper plate was thus secured to science.

The vanity of the patrons was well recompensed by the grand display of their armorial bearings and surrounding accessories, or the titles.

For a time, these grand picture books prevailed, but there was progressing a degree of observation and exploration in all parts of the world that had never been known before. Just before and during the time of our revolution, in the last quarter of the eighteenth century, there were numerous authors on *Mollusca*, *Insecta*, *Crustacea*, and the other lower invertebrates; zoology was advancing with amazing rapidity.

In England, the progress was now not so rapid, judging from the comparative paucity of zoological publications. Invertebrate zoology had from the earliest been only incidental in its development with the higher branches. The celebrated British zoologist Pennant, a scholarly man, gave an impetus to the science which it greatly needed. White, of Selborne, with his fascinating popular talk, stirred the young and old with the descriptions of nature's wonders seen at our very doors.

Scopoli, a botanical professor at Pavia, produced an "Entomology of Carniola," 1763, one volume 8vo. He does not follow Linnæus implicitly, and adds some new genera. He writes, however, in the true spirit of the *Systema Naturæ*. He was author of three other works on natural history. Later, Schoeffer, of Ratisbon, published his expensive and voluminous *Elementa Entomologica*, Regensburg, 1766. It relates chiefly to the insects of his native province. Though poorly executed, the figures are yet regarded as valuable for reference. He, too, endeavored to set up a system of his own, recorded in the above work. Curiously, he did not use specific names. Schoeffer was a clergymen, of moderate abilities, but industrious as a writer.

The immense number of new species of insects now accumulated required the genius of some competent naturalist to arrange them in harmony with the system then prevailing. Fabricius, the favorite disciple of Linnæus, commenced in 1775 to publish the voluminous matter. He was so impressed with the opportunity for a new scheme of a natural system, like many others, before and since his day, that he devised an entirely new method, and succeeded in making his arrangement more artificial than that he had pretended to build on. His generic characters were founded entirely on the mouth and its parts. Linnæus had practically resigned all attention to entomology, in favor of his pupil, Fabricius; consequently, the latter naturally became the acknowledged leader in that branch of science. The considerable length of life and the great amount of writing of this naturalist caused him to be thus prominent during a period of thirty years. He lived to witness the change in his system, and to see and feel the influence of Latreille's transcendent genius.

Some eminent disciples of Linnæus yet prevailed, particularly in entomology. Among them were Thunberg, one of the master's most notable followers, though identified with botany mainly; Müller, whose excellent Fauna of Denmark and Norway was published in 1775; Forster, the companion of Captain Cook, who wrote on insects, including a Catalogue of British Insects, 1770–1; and Villers, who made an attempt, even at the late period of 1789, to reduce all the genera of Fabricius to the standard of Linnæus.

Schrank, "*Enumeratio Insectorum Austriæ Indigenorum,*" 1781, 8vo, proved an original investigator and systemist.

Two important illustrated works of this period are those of Olivier, "Natural History of Insects," Paris, 1789–1808, five volumes, 4to; and Reaumur, "Genera of Insects of Linnæus and Fabricius," 1789, 4to. The latter especially has beautifully drawn figures.

The *Aurelian* of Moses Harris is conceded to be the most excellent work up to that time. The full title is: "The Aurelian; or Natural History of English Insects, namely, Moths and Butterflies," London, 1787, folio. Several other quartos and octavos were published previously. Drury's specimens were handsomely illustrated, as is well known, by this notable artist. Albin, Weeks, and Donovan are also on record as responsible for more or less valuable works. Cramer published in 1779 a treatise on exotic lepidoptera. Unfinished by Cramer, it was completed by Stoll; comprising, in the whole, 442 plates. A fifth volume is wholly by Stoll—Amsterdam, 1791, one volume, 4to—and is enriched by several representations of larvæ and pupæ of Surinam. This work is considered of much value.

Pallas, "*Miscellanea Zoologica,*" Berlin, 1776, 4to, commenced a crusade against Ellis and his advanced ideas of the nature of corals and polyps in general, maintaining the notion that they were vegetables.

Ellis, in his indignant state of mind, wrote to Linnæus: "There is now printing in Holland a book on zoophytes, by Dr. Pallas, of Berlin, who was two years in England. This gentleman, I find, has treated both you and me with a freedom unbecoming so young a man, etc." Some animus of personal nature comes to light in a further perusal of his letter.

Pallas was attached to the Court of St. Petersburg for many years, and travelled extensively in Asia and Europe. He is credited with having described the objects he saw with more than usual accuracy. He was a good comparative anatomist, and having no other occupation, but devoted to natural history, and living to an advanced age, he accomplished much, both in botany and mineralogy, as well as in zoology. Catharine II.

engaged him to travel through the Russian provinces in Asia in order to investigate the natural productions of the region. Having a munificent patron, his works received the most elegant attention from the publishers, and were translated into French and English. Pallas was doubtless the most accomplished naturalist of the Linnæan school. Though not an original worker or discoverer, he accomplished an amount of useful work in other directions. In this year, 1779, two other authors appeared, Schroeter and Born, whose works are illustrated by figures on shells; the former on "river shells."

It is notable that the very last work on entomology published in England that is arranged in accordance with the Linnæan system, "The Natural History of the Rarer Insects of Georgia, Collected from Drawings and Observations of Mr. John Abbott." London, 1797, two volumes, folio, J. E. Smith and Abbott, was acknowledged to be the best and most beautiful of any extant but few years since. The editor of this publication, Sir James Smith, was the possessor of the Linnæan museum, and the originator of the Linnæan Society. His labors are mainly connected with botany, but in entomology he is favorably known. The plates of his work are the last and best of the eminent Harris. The three volumes of Sepp and those of the latter author were considered to be eminently superior to all others.

Berkenout, "Synopsis of the Natural History of Great Britian and Ireland," London, 1795, two volumes, 8vo, and the plates of Lewin, father and son, "Natural History of Lepidopterous Insects of New South Wales," London, 1805, one volume, 4to, are of permanent usefulness.

Otto Fabricius is a name familiar from the earliest of the students' observation. His "*Fauna Groenlandica,*" 1790, is valuable in itself, and for a time was alone in its theme. Olivi, two years afterward, wrote on the marine objects of the Gulf of Venice, presenting new shells and crustacea.

Ernst and Engrammelle, "*Papillons d'Europe, peints d'après Nature,*" Paris, 1779–93, eight volumes, royal 8vo. This is a remarkably fine work. Some portion of Volume VIII. is exceedingly rare. The letter-press is by Father Engrammelle, an Augustine monk, and is simply the description of the figures. The work of Esper, a painter of Nuremberg, Erlang, 1777–94, "Lepidopterous Insects of Europe," is similar to the latter. Five volumes were published. The work is scarce. A third expensive volume on the Lepidoptera of Europe, by Hübner, was produced at this time. He was a German draughtsman, and is credited with having produced more on this subject than any other of the time.

In 1782, a voluminous and expensive work was commenced by

Herbst and Jablonsky, "The Natural History of all Known Insects, Indigenous and Exotic." Berlin, 1782–1806, twelve volumes, 8vo, and twelve volumes, 4to; plates. It was discontinued before its completion. The figures of some of the volumes are copies, and few exotic species are seen in them not before published in Cramer and Stoll.

"A Synopsis of Coleopterous Insects, etc.," by J. E. Voet, Erlangæ, 1794, 4to, has accurate, though coarse, engravings. The descriptions and nomenclature are worthless.

A work on the "European Hemiptera," I. F. Wolff, 1800, 4to, is excellent. In description and figures he is superior. Schellenberg, a painter of Zurich, produced a work on the same subject, "The Hemiptera of Switzerland," 1800, and one on the "Diptera," Zurich, 1803.

Edward Donovan, "Natural History of British Insects," illustrated with figures; London, 1792–1820, sixteen volumes, royal 8vo, and "General Illustrations of Entomology, etc., etc.," London, 1798–1805, three volumes, 4to. These works are familiar to all lovers of this branch of zoology. The figures are too highly colored in many instances, and sometimes the descriptions are not accurate. In the three quarto volumes, where a great many new forms are shown, the matter is of great usefulness.

Works of Uddman, Barbut, Bradley, Martyn, and Marsham, and some few others, are of minor consequence as entomological productions. Panzar, "Insects of Germany," or "*Deutschlands Insecten*," 109 fasciculi, 24 plates, one volume, 12mo, Nuremberg, 1813. This is regarded as a very reliable work. The figures are by the famous Sturm, then the best entomological artist on the continent. The descriptions are most accurate and satisfactory; the system of Fabricius is followed.

Professor Petagni published a valued pamphlet on the "Insects of Lower Calabria," Naples, 1786, 4to, and another called "*Institutiones Entomologicæ*," Naples, 1792, 8vo. These aided in spreading a taste for the subject in Italy. Rossi, of Pisa, through his "*Fauna Etrusca*," 1790, two volumes, 4to, and "*Mantissa Insectorum Etruriæ*," Pisis, 1792, one volume, 4to, had ably illustrated the entomology of Italy.

In 1798, Paykull, "*Fauna Suecica, Insecta*," Upsaliæ, 1798, three volumes, 8vo—treated the coleopterous insects of his native country. Laspeyres is another author on entomology of this era. "*Sesiæ Europææ*, etc.," Berolini, 1801, 4to, which is well esteemed. Dillwyn, "A Descriptive Catalogue of Recent Shells, arranged according to the Linnæan System," London, 1817, two volumes, 8vo, is like Viller's, who tried to bring insects under the headings of Linnæan genera.

Naturalists, strongly imbued with the Linnæan spirit, were now returning from their travels; bringing with them stores of new objects. Hasselquist published his narrative in 1757, on his Eastern travels. Osbeck came home from China, with plants and animals. Forkal published his "*Descriptiones Animalium.*" etc., 1775, relating to his observations on the Red Sea and the Desert of Africa. Sparman travelled in South Africa and China, and published *Museum Carlsonianum*, 1786. Each succeeding edition of *Systema Naturæ* became additionally bulky.

Drury is a name familiar to all entomologists, as the author of beautiful works. He was a wealthy jeweller, and expended large sums on his favorite study—sending out practical collectors in all parts of the world to enrich his cabinets with new insects. Mr. Henry Sweathman, one of Drury's collectors, first brought to notice the facts about white ants, published in the "Philosophical Transactions." Martini's great work on general conchology, now appeared, published in Germany in eleven quarto volumes. Notwithstanding the work was poorly illustrated, it is referred to at the present day as of some value.

The writers entitled to the designation Linnæan are now enumerated, with one exception, Dr. J. F. Gmelin. The thirteenth edition of the *Systema Naturæ,* 1788, enlarged and reformed by Gmelin, convinced many naturalists of that day that the time had come for advancement in the methods, now rapidly exhibiting, through the immense accumulation of material, lamentable incompleteness. Such had now become the condition of zoology. No one man could be expected to master or revise the entire subject with reference to appropriate and true systematic arrangement. Gmelin was nothing more than a compiler, but he made a satisfactory summary of the knowledge then extant.

Bonnet, of Geneva, published "*Traité d'Insectologie,* Paris, 1745, two volumes, 8vo. Baron DeGeer, in 1752, gave to the world his celebrated "Memoirs on Insects," seven volumes, 4to. This work has received unqualified praise from entomologists of late times. Its views on natural arrangement are of superior merit. The work is, unfortunately, nearly unprocurable in this country. M. Adanson, "*Histoire Naturelle des Coquilles du Sénégal,*" Paris, 1757, one volume, 4to, following Lister, was one of the first to arrange shells according to the structure of their animal or soft parts.

J. G. Fussely, "*Archives de l'Histoire des Insectes,*" Winterthorne, 1794, 4to. This work is regarded as instructive, and the plates are well executed.

The narrative style has hitherto prevailed largely. It was now felt that true scientific zoology could not progress without more consideration for system.

The mass of general knowledge and the natural culture of the human mind called for a more dignified and scholarly view of zoology. France now took the lead, and appreciating the value of system as then exemplified in the Linnæan school, began to review its proportions and reconstruct, more or less, its weaker points, and supply its deficiencies as well as might be in the present state of the science. Lamarck, Cuvier, Latreille were the luminaries of the then present horizon. Lamarck undertook the invertebrates; Cuvier assumed care of the vertebrates, and Latreille made special observations on the class then termed *Annulosa.*

The work of Lamarck, "*Histoire Nat. des Animaux sans Vert.,*" was produced in seven volumes, 8vo, in 1815. The "*Régne Animal,*" of Cuvier was issued in 1817. Latreille wrote his "Genera," . . . in 1806.

From the days of Linnæus, our ideas of nature rapidly became more defined and rational. Species of animals came to light in an amazingly increasing ratio. Even the genera of Linnæus would not accommodate them. There were new objects that required new genera to be framed to admit them. The more enlightened investigators of this period found it incumbent on them to look carefully into the state of the prevailing system. They also found it necessary to look closely to the structure of animals. The study of interior anatomy was growing to be serviceable. Cuvier had taken the science of zoology by storm; it was all hail to the great French savan, and by unanimous consent, Cuvier was the master and leader of the time. His great success led naturalists to believe that internal anatomy was the essential basis for classification. The enormous increase in the number of species of invertebrate animals brought home by scientific observers and travellers caused an extensive reconstruction and important invention of members of the edifice of classification.

Geoffroy St. Hilaire is a notable name in this connection. In the anatomy of *Mollusca,* Poli and Savigny were elucidating and contributing largely. Entomology, Cuvier trusted to Latreille; the master, as is well known, devoted his energies greatly in geology, in the treatment of fossil vertebrate remains. Like the *Systema Naturæ* of the illustrious Swede, the "*Régne Animal,*" of Cuvier, will stand as a beacon to mark the period of a bygone era.

The exquisite works of Poli, on the "Mollusca of Sicily," are viewed of great value.

A plan of a simple scale in nature had long been on the minds of zoologists, but was now nearly abandoned. Lamarck, however, gave great attention to the subject.

Fischer, the Russian naturalist, also had the same thought—neither knew of the other's possession—a theory that there were double lines of progression, which, deviating, came together again. Fischer published his opinions in 1808. It is an interesting fact that four naturalists of different countries, including MacLeay, the publisher of *Horæ Entomologicæ*, and the celebrated Fries, the botanist, equally ignorant of the thought of each other, should all have directed their studies to the same end, demonstrating the existence of one universal law in natural arrangement, and raising zoology for the first time to the rank of a demonstrative science.

Here, then, near the commencement of the present century, the archives of zoological science exhibit the well marked commencement of another, the present era.

The great activity of Cuvier in the earlier part of this century in building up the *Jardin des Plantes* soon led to the preparation by the French government of extensive exploring expeditions. Napoleon patronized the sciences with great liberality, always selecting eminent academicians for the various staff appointments in special departments of science. Savigny, Péron, Quoy and Gaymard, Langsdoff, and Lesueur were among them.

British entomology had been handsomely treated by Kirby and Spence. They broke away from the Linnæan bonds, and to-day their works are valued for considerable excellence. Dubyell, in his observations on the *Planariæ*, in 1818, exhibits a happy faculty for investigating the habits of aquatic animals. Leach on the annulose animals is an important work. DeBlainville and von Baer, Rathke and Wolff were identified with embryology. Later, Corte, Bischoff, Reichart, Kölliker, Vogt, and Agassiz gave attention to the subject.

In 1802, the Chevalier de Lamarck produced his remarkable doctrines and speculations, embracing among other views the belief that certain variations in species are produced under the influence of external agencies. In fact, the doctrine of evolution here first found definite expression.

In 1809, his *Philosophie Zoologique* was issued; but this was long anterior to the time when the microscope, the sciences of embryology, of histology, the doctrine of the cell, and before the principles of palæontology were established. Lamarck and his theories had fallen into obscurity; his doctrines had been received with contempt.

Over a half a century has passed; Darwin, Wallace, and the botanist Hooker have revived the doctrine of variation, and insist on its application. The theory of natural selection put forth by Darwin, and its unprecedentedly rapid adoption, is one of the best known circumstances of the present day.

The influence on the species of change and environment is a condition advocated by Lamarck and St. Hilaire. The tendency to variation by natural selection is the favorite view of Darwin. The influence of such minds as Cuvier and Agassiz was sufficient to extinguish any rising popularity of Lamarck's views; but while Agassiz stoutly maintained his antagonism to the heresy (as he viewed it) of Darwin, the doctrine of evolution has boldly advanced, and well-nigh threatens the foundations of the hitherto prevailing zoological orthodoxy. Lamarck noticed the variation of species, both in animals and in plants. He divided the animal kingdom into vertebrates and invertebrates; he founded the Classes Infusoria and Arachnida; he separated the cirrhipeds from the mollusca, and he was the first to construct a phylogeny, or genealogical tree of animals.

Wagner, Martins, and Plateau succeeded Lamarck. Kölliker, in Germany, is notably connected with questions of morphology and development.

In 1803, Russia sent out expeditions accompanied by Tilesius, Langsdorff, Chamisso, Eschscholtz, and Brandt, German naturalists by birth. The United States, in 1838–1842, sent an expedition around the world under Commodore Wilkes, with whom Dana, Couthouy, and Peale sailed as scientists.

The rich results in the several branches of *invertebrata* were due to the distinguished services of those naturalists. Dana's magnificent atlas on corals, and his reports on crustacea, through Stimpson, are well known.

The later United States expedition, under Commodore Ringgold, wherein Stimpson acted as chief naturalist, was fraught with great benefit to the various departments of of invertebrate zoology, though sadly enough the collections were destroyed by fire. The specimens were in the hands of Stimpson, then Secretary of the Chicago Academy of Sciences. This and several other circumstances connected with that disastrous fire proved most discouraging to Stimpson; his health being broken, he did not long survive.

Sars is a name familiar to all students of marine zoology, especially in connection with that of northern Europe. His death, lately announced, is a cause of sincere regret.

Of the literature of this theme, there were extant, in the first half of this century, R. E. Grant's "Lectures on Comparative Anatomy," 1833–4; Wagner's, 1834–5; Owen's "Lectures Comp. Anat. of Invertebrates," 1843–55; Siebold, "Invertebrates," 1845; Rolleston, "Forms of Animal Life," 1870; Huxley's "Invertebrates," 1877; and Gegenbaur's, 1874, are among the most modern. The latter is written in the interest of evolution. In 1859, Darwin's "Origin of Species" made its appearance.

Alfred Wallace, at the same period, visiting the Malay Archipelago, curiously arrived at similar conclusions to those enunciated in that work. H. W. Bates, during his observations on the Amazon, also came to like conclusions. Fritz Müller, Haeckel, and Weissman are also identified with the same line of thought.

In this country, Hyatt, Cope, Dall, Ryder, and Packard are supporters of the doctrine. The well-known names of Huxley, Spencer, and Asa Gray are prominent expounders. In Germany, Semper is its prominent representative.

The year 1839 commenced a period notable for the appreciation, by Schwann, of the animal cell. Valentine, during the same year, adopted terms for the expression of the new views. The cellular theory was then given to the scientific world. In 1665, Robert Hooke distinguished the cells of plants, and termed them cells and pores. The terms nucleus and nucleolus were applied by Schwann.

Dujardin and W. Schultze had determined that protoplasm, a word invented by Purkinje, is the basis of life, and the cell the unit of organization.

Carney, in "*La Biologie Cellulaire*," published the history and facts relating to the doctrine of protoplasm, and its identity in both animal and vegetable tissues or cells. The term "sarcode" is used by Dujardin at this period, but has since become well-nigh obsolete.

Brüke, Kühne and Schultze were now, 1861, active in this line of study. The treatises on embryology by Agassiz, Haeckel, Von Baer, and Packard, and latterly by Balfour, in "Comparative Embryology," embody the most advanced views in this line of study.

The discovery of spermatozoa, by Leeuwenhoeck, in 1677, and the mammalian egg, by Degraaf, were important events in the progress of embryology.

Remak, in 1850, exhibited the existence of three germinal layers. Huxley, in 1859, pointed out the homology of these with the tissues of the cœlenterates. Hertwig, Lang, and Sedgwick followed in a still further elaboration of this subject.

Among others identified with the elucidation of the structure of the invertebrates may be mentioned Hyatt, whose labors with the sponges and the ammonites are notable for great value, and Meek, Leidy, Marsh, and Cope. In Europe, the names of Boisduval, Bouché, Wyville Thompson, and his associates of the *Challenger*, Von Suhm, Moseley, in 1872–76, are associated with work destined to enduring fame. So, also, is the *Porcupine* expedition, whose naturalists were the eminent Carpenter and Jeffreys.

Among most active agents of progress in the study of *Invertebrata* may be classed the numerous sea-side laboratories. In 1873, Agassiz established at Penekese, in Buzzard's Bay, Massachusetts, a laboratory for teachers and for students of natural history, particularly of marine animals. Its location did not suit the purpose, as there were few marine productions to be obtained without going to a considerable distance. Curiously, there were abundant species on either side of them. This station was given for the purpose by Mr. Anderson, of New York, and, in all respects, save the one mentioned, was admirably adapted for the purpose.

Johns Hopkins University now established a laboratory in Chesapeake Bay, which is yet doing much good work. Subsequently, Alexander Agassiz formed a private establishment for the study of marine forms at Newport. The fine Italian laboratory of Naples was now formed, as is said, through the examples above mentioned; its success has been perhaps beyond all others.

Lacaze Duthiers, at Roscoff, *Banyal-sur-Mer*, in France, has also established a similar laboratory. Prof. Hyatt's, at Annisquam, has become a regular school, and accommodates a certain number of students each summer, his yacht being in constant use for dredging. Prof. Packard for several years maintained a summer school of biology at Salem, Mass., in connection with the Peabody Academy of Science.

Of American zoology it is known that its true commencement dates from 1796, when John Barton published, alternately in Europe and this country, his memoirs and zoological tracts. Systematic zoology was even later, when Wilson and Prince Bonaparte appeared in American ornithology, during the years 1808–14. Harlan came on, in his "Fauna Americana," 1825. Dr. Godman was now the prominent anatomist and naturalist. Thomas Say produced his elegant works on American entomology, 1824–28, and subsequently on conchology. Philadelphia was now the acknowledged home of American zoology.

The Academy of Natural Sciences of Philadelphia, organized in 1815, was a centre of influence. In the city of New York, our society, then the "Lyceum of Natural History," dating from 1817, helped on the work, and the names and labors of many authors are given an imperishable fame in our "Annals."

In 1847, an important period for this science began. The Smithsonian Institution, established through the liberality of Joseph Smithson, an Englishman of wealth, was organized; Joseph Henry was chosen its head or Secretary, and Spencer F. Baird its Assistant Secretary.

An important impetus was given to zoological studies through the extensive explorations instituted by the U. S. Government.

The several geological surveys necessarily carried with them the requisite scientists in the field. We may now look with pride and gratitude on the liberality that has made it possible to produce such magnificent volumes as we now see, the product of our Government press in every library of science.

There is another very distinct period in the history of American zoology, dating from the advent of Agassiz—in the words of Cuvier, "a pearl from the hills of Neufchatel." To those who are able to look back to this event, its appreciation is most heartily recalled. The generous enthusiasm of the master was instantly contagious, and continued. The eminent *savant* found many collectors, but few investigators in our country. In the glorious school of Cuvier he had been taught to observe. The mere collection, arranged and labelled, was to him meaningless: what to him the empty shell of a periwinkle, or the impaled carcass of a beetle, so there be no story of its life, nor appreciation of its mysteries in death?

It was our good fortune frequently to meet this delightful man during the first years of his residence in our country. His cottage and laboratory at Nahant were near our home. His frequent presence on the rocky shores and sandy coves and beaches seemingly induced a sort of talismanic power that called up many an unfamiliar form from the vasty deep.

The rapidity with which new forms of invertebrates came forth, having now for the first time, by the magic hand of the master, "a local habitation and a name," was marvellous to all. The work, subsequently accomplished by Agassiz and his assistants, is historic, and many a disciple of the master has become illustrious through his teachings.

During the latter years of the first half of this century, the Boston Society of Natural History and the Essex Co. Natural History Society, Eastern Massachusetts, were organized; the former somewhat earlier perhaps. The works of Dr. Gould on the *Mollusca* we have noticed. But there was a good deal of private observation and investigation that either never passed into print, or was simply deposited in the archives of the Essex Co. Society. Salem, Mass., was headquarters of the society, and a very respectable museum was established there, and has continued growing apace until the present. It is one of the few thoroughly scientific museums in this country.

The names of Dr. Wheatland, Putnam, Cooke, Tufts, Haskell, True, Stimpson, are remembered with sentiments of high esteem. Here and in the adjacent towns much of the first work in this branch of zoology was done. Mr. True was a carver in wood, entirely dependent on his daily labor; yet he contrived to make some of the earliest observations on the habits of molluscous animals known here. Several others contributed to the early numbers of the annals of the society. Mr. Putnam's work on the fishes is well-known. To extend observation and studies of the lower forms, especially at that time the molluscs, it became necessary to visit the sea shores at particular places. An interesting period in this history of searchings for invertebrates is just before the trial of steam-dredges, and their use in deep water; when the deep-sea forms were rescued from

"The maw and gulf of the ravined salt sea shark,"

and by courtesy of the fishermen of Swampscott, or Nahant, the cod and haddock yielded the contents of their interior; when the halibut, from the greater depth, responded with pelagic forms; when, too, the diabolic cat fish, *Annarachus*, fresh from the deep, rocky beds, offered up some choicer morsels, the delicate *Velutinas, Bullas*, and equally fragile bivalves. These were days of enthusiastic working, though the subject and the period of the year, the coldest, were not naturally inspiriting.

William Stimpson, whose memory we revere, in his boyhood days was one of the little party present always when such an expedition was forward. Some of the first hand-dredging was done here in those days. The works, now prominently extant, of William Stimpson, contribute to a fame well established as eminent in the ranks of authors of invertebrate zoology.

These somewhat personal items, connected with the early history of invertebrate zoology in North America, may show how recently this branch of science was in its infancy here.

We have seen how much the Smithsonian Institution has accomplished through its organization, and by means of the various United States surveys in the great West, which have been planned and fostered by the officers of that institution, but we have to add another important element in the progress of Invertebrate Zoology, that of the U. S. Commission of Fish and Fisheries. The facilities offered for study by this Commission have been, and still are, of untold value. The peculiar position of its eminent commissioner, coupled with a natural capacity and whole-heartedness in the love of science, and with singular readiness to aid every student that may be benefited by the extension of such privileges, places the pursuit of the several branches of marine zoology under conditions at once the most accessible and liberal.

The workings of this Commission are familiar. The long continued complaints of the citizens of Massachusetts and Rhode Island, that the food-fishes of the coast were steadily becoming reduced in numbers, eventually caused an application to Congress for the appointment of a Commissioner. The immense amount of labor done by Prof. Baird and his corps of scientists, is well set forth in the numerous large volumes and bulletins already published by the Commission.

The special work done by Prof. Verril, S. I. Smith, and others connected with the commission, is seen in the valuable reports and tables of local faunas extant.

In 1883, the Austrian Government as well as the Portuguese and French sent out expeditions. That of the *Talisman*, A. Milne Edwards, naturalist in charge, obtained excellent results.

Agassiz, Desor, Pourtales have opened rich mines at the deep sea bottoms.

In 1796, when Barton published his memoir on the "fascination attributed to the rattlesnake"—there had been little to entitle the country to a claim for original work in zoology. The great revolution was enough for one generation to cope with—without spending time in "bug-hunting," our most practical people would say.

Among the earlier writers on conchology, Say and Gould are preeminent.

The latter produced a beautiful volume as one of the reports called for by the State of Massachusetts. It is an octavo, with copper-plate engravings of each species of mollusk then known as inhabiting the Massachusetts coast. No figures of natural objects have ever excelled those of this volume for accuracy and artistic treatment. Say's work was more elegant, and the engravings excellent. The finest of these copper-plates were executed by the wife of Say, who learned the art and completed the plates after the work was delayed by the want of a suitable engraver. The venerable widow of Say is yet living; an example of the courtly, cultivated lady, worthy associate of the brilliant coterie, literary and scientific, that formed an important element of Philadelphia society. Audubon, Wilson, Prince Bonaparte, Isaac Lea, Conrad, Lesueur, the eccentric Rafinesque, and others are remembered with singular reflection, when we come to appreciate the fact that very few have come forward to fill the places so worthily occupied.

"American Entomology" by Thomas Say, was published in 1824–28. His conchology was issued later.

American works on mammals and birds were now appearing, Harlan, Godman, Bachman, Ord, Audubon, Wilson; but those on invertebrate forms were few, and mostly confined to transactions of societies. Though the mollusks had received considerable attention, there had been little done in the study of their anatomy. The other and lower forms of invertebrates occupied in Dr. Gould's report on the "Invertebrata of Massachusetts" only thirty-two pages, and most of the matter related to "noxious animals."

In entomology, besides Say, were the two Le Contes, Melsheimer, Von Osten Sacken, W. H. Edwards, Scudder, T. W. Harris, Haldeman, Hunter, Clemens, Uhler, Hagen, J. D. Dana, and many of later date, names now familiar to all through their valuable labors.

The great work of Dana on the "Crustacea of the N. E. Exploring Expedition" stands as a monument to his fame as an observer and investigator. Say and Stimpson, Randall, Gibbs, Packard, Kingsley, Hager, Faxon, Herrick, Birge, Lockington, and S. I. Smith, are prominent names in this department of sciences.

The *Vermes* have received attention from Leidy, Girard, Stimpson, Minot, Webster, Wyman, Verrill, Benedict, Sager, Wright, and Whitman. The Brachiopods have been studied largely by Dall and Morse, and the Polyzoans by Hyatt.

The mollusks of North America have been studied by Say, Gould, Lesueur, Rafinesque, Haldeman, Lea, Conrad, Anthony, Adams, Stimpson, the Binneys, Mighels, Conthouy, Bland, Prime, Morse, Verrill, Sanderson Smith, Dall, Tyson, and others.

The anatomy of molluscs has been elaborated by Leidy, Wyman, Morse, Dall, Brooks, and Osborn. Sharp has studied especially their visual organs.

The *Cœlenterata* have been observed and studied by the two Agassiz, by Say, Stimpson, Desor, Ayres, McCrady, H. J. Clark, Lyman, Verrill, Brooks, S. F. Clarke, Feukes, and several others.

The *Porifera* have received very close attention from Hyatt, Clark, Potts, and Mills, and the *Protozoa* from Leidy, Bailey, H. Jullask, Stokes, Ryder, and Kellicott.

November 23, 1885.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the Chair.

Thirty-five persons present.

A paper by MR. GEORGE N. LAWRENCE was read by title:

CHARACTERS OF TWO SUPPOSED NEW SPECIES OF BIRDS FROM YUCATAN.

These are named *Polioptila albiventris, Chætura peregrinator.*

(Published in the Annals, Vol. III., No. 9.)

MR. R. M. CAFFALL read a paper on

THE PRESERVATION OF BUILDING-MATERIALS BY THE APPLICATION OF PARAFFINE, AS RECENTLY USED UPON THE OBELISK.

(Illustrated with apparatus and experiments.)

In discussing the subject of waterproofing and preserving building-materials, it will be necessary first to consider the causes of decay in such materials, and how it may be prevented.

The most powerful natural agent that disintegrates stone and other similar building-material is undoubtedly water, especially when it freezes after it has entered into the interstices of the stone, as it then exerts a force that is irresistible.

Mr. Dexter A. Hawkins has told me that he had seen in the New England States immense boulders of granite near the roadside which had been so powerfully acted upon by freezing water, that it was the custom of those living there, when they required material for repairing roads, to back their wagons up to one of these apparently indestructible masses of rock, and by simply striking it with a pick, it would crumble into small pieces, which were then shovelled into the wagon, drawn away, and spread where required. He also mentioned having seen in the cañons of Colorado, and elsewhere in the West, immense banks of débris, one hundred feet or over in height, formed of matter forced off by frost from the face of the rock cliffs above.

The evidence that water is the most destructive agent can be seen on any building where the exposed stone remains the longest in a wet state, as, for instance, the base of the wall near the ground, the stoops, the stonework under balconies, porticos, window sills, etc.

But there are also other causes of decay, the chief one, in my opinion, based on long and careful observation, being the white salts which are so often seen upon our best buildings, those of brick more particularly. They are especially ruinous to building materials, are most difficult to overcome, and hence deserve extended notice.

(1) As to their Origin.—These salts exist naturally in the clay from which the bricks, terra cotta, etc., are made; also in the lime used for mortar or cement. It is a well-known fact that many of the salts that are present in clay are insoluble while the clay is in its raw or natural state, but that the action of fire renders them soluble. The same result also follows the admixture of lime with the clay. Hence, agriculturalists apply lime to the clay soils to render them more fertile, because the salts are made soluble by the action of the lime, and the plants are then able to assimilate them.

(2) As to their Elements.—These salts consist of carbonates, sulphates, nitrates, and chlorides of sodium, potassium, calcium, magnesium, etc. Sometimes several of these salts are associated in one sample, taken from a building, and in nearly every instance that has come to my notice, I have found a difference of constituents and proportions; so much depending upon the clay and how it is burned, and the character of the limestone used for the mortar or cement. Hence arise the apparently contradictory statements and opinions expressed by chemists and others as to what these salts are composed of, some claiming one thing, and some another; and I have no doubt that each may have been correct in his analysis, though, perhaps, widely differing from the others. I have taken two samples from the same building, and found them dissimilar. I believe that every kind of brick, cement, and mortar contains soluble saline ingredients.

(3) The causes of their appearance.—This is wholly due to moisture in the masonry. This dissolves the salts, forming a weak brine which, upon coming to the surface, loses its water by evaporation, and leaves the salt to crystallize and form the objectionable efflorescence.

The presence of the moisture may be due to the water used in mixing the mortar or cement, or in wetting the bricks; or it may be absorbed from the rain falling against the walls. Hence the drier the walls are kept during the erection of a building (consistent with making the work good) the less chance will there be for the salts to show themselves, and if the walls can afterwards be kept perfectly dry, the salts remain inert and do no harm, because water is the agent that renders them active and effective in their resolving powers. It may sometimes be seen which parts of a building were built in dry weather and which in wet, by the appearance of the mortar joints at different elevations, especially on old brick structures.

To attempt to wash the salts off, only results in their being dissolved and absorbed by the bricks, to re-appear as the bricks dry. Rain does not wash them *off*, but *into* the surface of a building.

(4) Other causes of production.—Salts of lime are produced by acids and alkalies contained in rain-water, especially that falling in cities. Some twelve years ago an eminent English scientist estimated the quantity of sulphurous acid gas given off by the coal consumed in London at 300,000 tons annually. The carbonic acid gas from the same source must have been many times greater. These two gases have a great affinity for moisture, and are readily taken up by the rain which falls against, and is absorbed by the brick-work, and are the most active agents in producing soluble salts of lime, and so causing it to dissolve to

appear afterward on the surface as previously described. Nitric acid, and also the alkali ammonia, act similarly. Their destructive effect on the mortar and cement joints is especially noticeable on the brick-work of the tops of chimneys that are in contact with the outflowing gases resulting from the fires beneath.

(5) Effects of these salts on building materials.—The alkaline property of some of these salts is very destructive to brick, stone, cement, and mortar, completely disintegrating them, as may be seen by careful examination of the places where they show; nor can linseed oil, paints, or similar compositions withstand them; the oil being saponified by the alkali and rendered useless, so that the paint is destroyed and falls away. I have seen these salts in the walls of buildings in England, nearly 150 years old, still active and troublesome. In Philadelphia on October 4th, 1882, I noticed the peculiarly white appearance of a great number of the houses, and asked if they had been whitewashed. I then learned that the whiteness was wholly due to an extraordinary quantity of these salts on the surface of the walls, caused by a three days' rain-fall that had occurred a few days before, and had completely saturated the brickwork, which, upon drying out had produced the efflorescence. It by no means follows that the brick, cement, and lime severally are not good, because they contain these salts, however undesirable these salts may be; in fact, I have constantly observed them in the very best qualities of each.

(6) Responsibility of the profession and trades.—Architects and builders are often blamed and held amenable for discolorations on buildings, and most unjustly so, when they are no more responsible for dirt settling upon and staining the walls, or for the salts that appear thereon, than are the shoemakers for our shoes getting soiled when we walk in a muddy street, or glaziers for our windows getting dirty from rain and dust.

Water will penetrate an ordinary brick; it will dissolve the salts in the walls, it will bring the same to the surface and evaporate and leave the salt to crystallize. Dust will float in the air and settle on exposed surfaces, and if rain can fall upon them, it will most assuredly penetrate and permanently stain them. These are natural causes and effects, and no one can be justly and reasonably blamed for such things happening.

About a year ago, I was requested to examine a large new building in this city; the front was of a light yellow brick. The owner was moving his goods into it. It had become, as usual, stained, and the owner was retaining a part of the money, refusing to pay either architect or builder because of these stains. After a careful examination, I told him that neither of them were responsible; that the front faced the North, had been very wet, vegetable germs had settled upon it and grown, and the rain had washed floating particles of dust into it; and that the architect and the builder ought to have their dues. I asked him if he had withheld payment from the glazier because his windows had become dirty. His reply was, Well, I will take good care that *you* don't see those parties; I said, You asked for my opinion on your building, and I have given you a true and honest one.

Here are for your inspection some pieces of brick taken a few days ago from a new building on 58th street near Sixth avenue. You will see it had been painted, and though the paint used was of good quality, as shown by its toughness, yet the destruction of the face of the brick and the forcing off of the coating of paint was wholly due to the caustic alkaline properties of these salts, which were brought to the surface and into contact with the paint by water. This effect can be seen, more or less, almost without an exception, on every brick house that had been painted with ordinary linseed oil paint. And if the paint thus perishes, so does linseed oil when applied alone, though the effect is not so readily seen. It is therefore neither durable nor effective. How often do we see the paint on a building peeling off the mortar joints and leaving them quite bare, this is due, as I have said, to the action of the lime salts in saponifying the oil.

Terra cotta shows these salts very much, in some buildings even more than the brickwork. This is noticeable on the new Produce Exchange Building. It is there caused, probably, by the liberal, though, perhaps, necessary backing of cement or mortar used to fill up the hollow spaces behind it, the salts of which come to the surface as before described.

Stone, especially in contact with brick-work, is damaged by the same cause. The water, no matter how it reaches the cement or mortar in a wall, will permeate through a stone, and bring with it these destructive salts, which quickly eat away the surface.

The late Mr. Francis D. Lee, a well-known architect of St. Louis, Mo., said he believed that the damage to property, caused by the weather and these salts, was at least $500,000 per annum in that city alone. If that was a correct estimate, who can compute the enormous loss to property owners in such a city as New York? The fact is, a certain amount of deterioration in house property is looked upon as a matter of course, as something inevitable, and therefore to be borne, like taxation, as philosophically as possible.

The question before us is, Can this disintegration be arrested or prevented? Can this natural law of decomposition be stayed? I believe it can, by shutting out or keeping off that destructive and ever active agent—water.

For the preservation of these building materials by water-proofing, the paraffine process is the most effective and lasting yet discovered. This statement is based, not on mere theory, but on many years of extensive application in varying climates, and on nearly every known kind of stone and building material.

I have had nearly twenty years of experience in this matter, sparing neither trouble nor expense to ascertain what is really the best thing to do. I have tried oils, varnishes, gums, rubber, and silica compounds, and made numerous experiments, but found no substance to have so many advantages and accomplish such perfect results as paraffine, applied with the aid of heat. It is imperishable, invisible, insoluble, impenetrable to water and gases, and it does not evaporate or waste away. It prevents the disintegration of stone, the weathering of brickwork, the crumbling of mortar-joints, the growth of moss and other destructive and unsightly vegetable organisms, the efflorescence of salts, and, in a word, it keeps buildings in a fresh, clean condition.

It renders the interior walls of hospitals, etc., impervious to the infectious emanations from the sick, thus keeping the wards healthy.

Although this may seem a large claim, yet every statement can be verified by accomplishment of successful work, extending over a long period and in many places.

The enemies of the exterior walls of our buildings are legion, but the strongest and, as I have shown, the ally of all, is unquestionably water. The particular deduction from this established fact therefore is: Keep your house dry, it will last longer, look better, cost less to keep in repair, and be more comfortable and healthy for those who live in it. Each and all of these advantages are worthy of the fullest consideration of all owners of house property.

The proper time to treat a building is immediately after its erection, and before it becomes permanently stained and spoiled. But it is difficult to make owners or builders appreciate this. The following incident is one of many similar experiences. I saw in this city a very fine building in process of erection, white brick with brown-stone trimmings. I knew it would quickly stain and be ruined. I brought this paraffine process to the attention of the owner; the front looked very fine indeed, though even at that time stains were beginning to show at the ends of the window-sills and other projections. The owner said the building was new, only just finished, and clean, and he did not see why it was necessary to do anything more to it. I replied, Now was just the time to do it, and to keep it clean. He said he would wait a year or two to see if it stained, and if it did, then he would have something done to it. I need scarcely say that "then" will be too late, for there is no known process that will clean and restore a white or light-colored brick front to its original appearance. It is permanently ruined. "Prevention is better than cure," for in this case, if a decent-looking wall is desired, after it has stained, it must be coated with paint or color, and that forever prevents the brickwork from being seen again, except in spots, in a dilapidated condition, where the paint peels off.

The discoloration of the terra cotta of the new New York Cotton Exchange is rapidly taking place in spite of its coatings of linseed oil, and its light yellow bricks will ere long look like those of the building on the opposite corner, William and Beaver streets, and those of the "Post" Building, on Beaver street and Exchange place, which are stained beyond the possibility of restoration.

A very important consideration with an architect, in designing a good building, is color—the proper blending of shades. But of what use is it for him to be so careful in selecting brick and stone of certain tints, and to see that the builder and mason execute good clean work, when in a few months after it is finished the whole of the beauty is completely marred by unsightly discolorations.

If it is worth while to spend time and money, and to take so much care in designing and erecting a substantial and handsome building, surely it is wise to spend a further comparatively small amount to permanently preserve the whole from the ruinous effects of the weather, which will surely follow exposure.

Let us now briefly consider in this connection a few of the stones used in New York buildings.

Brownstone is a popular stone, and deservedly so. There is a very substantial look about a brownstone house. The stone has a beautiful grain and sparkle, and does not, on account of its color, readily show the weather stains which are sure to occur in a city. But the chief objection to it is its liability to decay. It absorbs water freely, and then the frost quickly disintegrates it. If bedded on a dry, water-proof foundation, and protected from the action of water and frost, there is no reason why it should not remain sound and good for an indefinite time, and the above objection to its use would no longer exist.

The entrance to the Greenwood Cemetery, at Brooklyn, a fine brownstone structure, is badly decayed. It is said that many things have been tried to save it, linseed oil and sundry solutions, but all useless, none lasting over a year; and the beautifully carved work, erected at a great cost, seems doomed.

The Carlisle or Scotch red sandstone, though very beautiful in its color and grain, is probably the most absorbent of all the building stones used in this city. It certainly stains very quickly and badly and cannot stand the weather. Any one can see this who will carefully examine any of it that has been exposed a year or two. Among the finest exterior work in New York is that on the front of the Hon. S. J. Tilden's house in Gramercy Park, where the principal part of the exquisitely carved stone is this same red sandstone. The discoloration and decay are very marked. In some places the costly carving is rapidly disappearing, a salt appears in many spots which is said to be due to the stone having been wetted by sea-water. Its extreme porosity, more than that of some kind of brick, is against its being able, unprotected, to withstand the attacks of this very trying climate.

The blue *Wyoming stone,* from Pennsylvania, is a very hard substantial stone, less absorbent, and consequently less liable to decay than the former stones; but even this is damaged where in contact with brickwork, the salts of the lime and brickwork being carried into and through the stone and so corroding away its surface.

The light-colored Ohio and Nova Scotia *sandstones* are good, sound, hard stones, but owing to their delicate color they show the weather stains and become very unsightly, and are sometimes almost covered with a green vegetable growth. A large quantity of Dorchester stone was used in Central Park, especially on what is called the "Terrace" at the north end of the Mall. Here, a few years ago, an enormous amount of money was expended in executing a great deal of fine sculpture, but, alas! its beauty is rapidly fading away. Some portions are almost obliterated, and there is scarcely any that is not seriously damaged.

There are many buildings here constructed of *marble* of various kinds. It stains badly, and perishes more readily than is generally supposed. The old building of the Mutual Life Insurance Company on the corner of Broadway and Liberty street was cleaned this summer. It was in a very bad state, and the stone near the top very much decayed. Some pieces of it here exhibited speak for themselves. I could dig into it in places a half an inch with my pocket knife. I have taken fragments of marble from old buildings in this city, and rubbed them into dust in my hand. You will observe that this piece of marble from the upper portion of the "Stewart building," obtained when the building was being altered two years ago, has quite perished.

Limestone, Oölites, etc., are not much used in New York, but where they have been, they show stains on their white surfaces, and abundant evidences of decay.

Granite is undoubtedly the strongest and most durable of building stones. But even it is not proof against the disintegrating forces. The *Obelisk* is unfortunately an illustration.

I saw the Obelisk for the first time about six months after its erection in Central Park. Being interested in the preservation of stone, I examined it as carefully as I could from a distance, and saw how rough the western and southern sides were, but, being unable to approach it closely, could form little idea of the actual condition of the surface.

On many subsequent occasions, I examined it closely, and after a time found small pieces of the granite lying around the base, which, to me, clearly proved that it was being affected by the severe climatic influences.

Professor Doremus accompanied me, about a year ago last September, to examine the obelisk. We gathered quite a quantity of it from around its base. He showed the pieces we had picked up to the late Commander Gorringe, who could hardly believe they came from the monolith, and expressed the hope that some day it would be polished. Hence Dr. Doremus refrained from pressing the matter of its preservation with the park commission.

On his return this summer from Europe, the then President of the Board, Mr. J. D. Crimmins, wrote to Professor Doremus requesting his opinion and advice, which resulted in his letter published last September.

The Hon. M. E. D. Borden was finally intrusted with the decision as to the proper treatment to be adopted. After consultation with Prof. Doremus, and a visit to the obelisk with him, Mr. Borden decided on the paraffine compound application. On September 22d, ult., we received a letter from the Park Commissioners requesting us to treat the north side of the plinth as a specimen of our waterproofing process.

On September 25th, my son and I went to the obelisk, and commenced the work, when I discovered that I could remove quite large scales with my finger-nails from the surface of the plinth, and also that there was a green vegetable growth behind each piece removed.

This was so serious that I thought it better to call the attention of the authorities to its condition before proceeding with the work.

It took my son and myself several hours to take off the decayed portions. We then applied the waterproofing compound. I watched very closely the effect of the heat upon the stone, as so much had been said against using it, and found that it stood the necessary temperature perfectly well, not being damaged in the slightest degree.

Professor Doremus was present and watched the operation and applied some of the melted compound himself and thus saw how readily the warmed surface of the granite absorbed the melted compound.

This accords with Professor Doremus' experiment, the year before, with a large piece of the obelisk given to him by the late Commander Gorringe, which he heated and dipped in melted paraffine wax, and found it to absorb it, the heat not damaging the stone.

I found, much to my surprise, that the stone absorbed the compound *very freely,* much more so than stone generally. This showed that there were many and large interstices into which water could pass; which, if frozen while there, would inevitably force off, with its resistless power, the surface of the stone. This confirms the experiments made by Professor G. W. Wigner, in 1878, respecting this stone, and published in the *Analyst,* which showed that "the absorbent power of the unchanged stone was at the rate of 7.8 grains per square foot; the weathered surface showed an absorbent power six times as great."

Some time afterwards, we received the order to proceed at once with the scaffolding, cleaning, repairing, and waterproofing of the whole surface of the obelisk and its plinth.

We commenced on October 27th ult., and the scaffolding was completed, in spite of bad weather and other hindrances, on November 2d. We then began the cleaning of the stone, and discovered what a deplorable condition it was in, far surpassing our worst fears. Some large pieces were so loose that they would scarcely bear the hand on them without falling away. Walking around the monolith on a plank, I put my hand against one of the hieroglyphics to steady myself, when it came off in my grasp. We found the greatest disintegration to be on the west side, very bad on the south, not so much on the north, and the least on the east, though decomposition had already progresssd to a serious extent, even on this side in certain places. We removed about two and one-half barrels of pieces, weighing altogether seven hundred and eighty pounds. Some of the flakes were so much decayed that even with the greatest care they would crumble to pieces when being removed. In quite a number of places we found the flakes, though separated from the stone and sounding hollow when tapped, yet seemingly firm in position. These we allowed to remain, if they would stand the heat. One especially large piece, which measured sixteen by seventeen inches, is on the base of the western face of the apex, or "pyramidion," and extending several inches down the western side. I consulted Commissioner Borden about it, and he said: "Don't remove any unless you are obliged to do so." I heated the piece carefully and saved it. To have removed it would have seriously disfigured the top of the obelisk. This plan was carried out all through the work, and there is a great deal of the surface which, though hollow, will now stand for a great number of years, which, had it been left unprotected, would soon have fallen away. When the work of cleaning had sufficiently advanced, we proceeded to apply the waterproofing compound. This was on November 6th, and we continued the work until November 13th, when all was finished. Some part of the time, the weather was very boisterous, one could scarcely stand on the scaffolding, the wind had such force, especially on November 9th and 10th.

As before stated, 780 pounds of pieces of decayed granite were taken from the obelisk, which proves beyond question that the stone, though only exposed four and one-half years, could not withstand the destructive influences of this climate.

What I have recently accomplished clearly proves also that certain statements made in the public press are unreliable, viz., the calculation "that it would require 58,056 years to remove from the plinth a shell one centimetre in thickness, and weighing 631,652 grams" (or 1,338 pounds avoirdupois), and that "the waste in a century would therefore be scarcely a perceptible amount," as well as the concluding summing up that "we need, therefore, be under no apprehension that the obelisk will seriously suffer from the effects of our climate."

Secondly, it proves that "the suggestions of certain foreigners, who had visited Central Park, and said that if the obelisk was not protected, the frosts and snows of our severe winters would soon make more of an impression upon the stone than the thousands of years under an Egyptian sun," were reasonable and well founded.

Thirdly, that "a hot compound could not be made to enter the stone, without the use of a greater heat than would be possible without injury to the stone," was a groundless fear, because the successful heating and applying of the hot melted paraffin compound to the surface has been actually done without causing any injury whatever to the stone. This is a fact, not an opinion or a theory, and it speaks for itself. But for these unfortunate expressions of opinions from high authorities, made through the public journals, doubtless the obelisk would have been treated years ago, and much of this valuable and interesting relic and record of the past, which has now been irretrievably lost to posterity, would have been saved.

It was feared by some persons, as I have just stated, that this waterproof compound could not be applied to the obelisk, without serious risk of injury. The trial has been made and no damage at all has been done, for, by a careful method of application, acquired by many years of experience, it was safely accomplished, and I do not think that a single particle of solid sound stone was displaced from the surface of the obelisk, by the application of the heat employed to enable the stone to absorb the compound to an effective depth. There were many witnesses to the correctness of this statement, some of whom watched especially for it. There were even spaces that were hollow beneath that were successfully treated. In some few instances where the pieces were very loose and had a green vegetable growth behind them, as soon as the stove had warmed the stone, the steam came out of the humble but audacious plant-life at the back of the loosened scale, and these pieces we removed.

I believe the compound penetrated to a depth of half an inch and deeper. The stone certainly absorbed it in considerable quantities, no less than $67\frac{3}{4}$ pounds having been used. The surface treated—shaft and plinth—is about 220 square yards. An equal surface of brownstone would have taken from 40 to 50 pounds. The work was effectually accomplished, and nothing was spared to insure a satisfactory result.

We did most of the work when the wind was blowing a gale from the northwest, and one squall that passed left our top poles covered with ice, though below it was simply a cold rain.

DISCUSSION.

MR. CAFFALL, in answer to inquiries, said that ordinarily one pound of the paraffine compound would cover two to three square yards of brick surface. The compound penetrates the stone only as far as the melting-heat penetrates. If some of the liquid remains upon the surface, it demonstrates that the pores of the brick or stone are completely filled to the depth reached. Then a reheating causes the absorption of this excess, and leaves the surface clear. By this method, the thickness of the saturated layer is under control. The melting-point of the compound is 140° F. It consists of paraffine, containing creasote dissolved in turpentine. The use of creasote prevents organic growth upon the surface. The compound, in its constituents and its proportions, is the result of many experiments and long experience.

PROF. R. OGDEN DOREMUS called the attention to the statement of Prof. Persifor Frazer concerning the rock of the obelisk, contained in the eighth chapter of Commander Gorringe's work on "Egyptian Obelisks," and read as follows: "The first thing that strikes one is the freshness and soundness of the rock. No *maladie de granite* is observable, and this fact will answer the first and natural question as to why this rock was so much preferred by the Egyptians for monumental purposes." Again, on page 167 Prof. Frazer says: "The rock of the Needle can, therefore, be regarded as unusually fresh and healthy, in spite of the honorable age which it possesses."

If we assume that this professional report was correct, said Dr. Doremus, how terrible the ravages of four American winters on this historic monolith and its plinth!

Commander Gorringe felt confident of the permanency of the obelisk, remarking, in a way to close all discussion, when Dr. Doremus broached the subject of some preservative treatment, that "it had lasted nearly four thousand years, and will probably last four thousand more." When a handful of small fragments picked up from the top of the plinth were shown the Commander, he could hardly believe they came from the obelisk. He expressed the hope that some day it would be polished.

During the past summer, while in London, Prof. Doremus had an interview with Dr. Birch, the world-renowned orientalist of the British Museum, and showed him the fragments from the obelisk. He was not surprised, and remarked: "You will next find that pieces will come off in flakes, or scale off." As a verification of the prediction, Prof. Doremus proposed sending, in his care, for the British Museum, a piece of the obelisk with hieroglyphic markings on it, which is now in his possession. The fragment or flake was twenty inches long, and from two to six inches broad, but so fragile that it broke in half while being removed.

Cleopatra's Needle was treated, in 1879, by Mr. Henry Browning, with a solution of gum dammar dissolved in benzin, to which a small a mount of beeswax was added, and a very small quantity of corrosive sublimate. Prof. Wm. Crookes had expressed an opinion that paraffine was unquestionably to be preferred as a water-proof coating for the obelisk. And inquiries regarding Mr. Caffall's treatment of public buildings with paraffine elicited only favorable replies.

Prof. Doremus also referred to the permanent character of paraffin and its use for resisting the action of the most powerful acids and alkalies.

Mr. P. H. Dudley made the following remarks: I visited the obelisk during the time Mr. Caffall was treating it with paraffine, and noticed particularly the flaking and crumbling of portions of the exterior surfaces of the shaft from forty feet above ground down to the plinth. Above this the staging was down.

I was surprised to find parts of the rock so porous and full of minute fractures on the exterior; and gently tapping the shaft with a hand chisel at once indicated the location of many loose flakes from one inch in area to eight or ten inches. Most of the fractures of the flakes seemed of recent origin, although under-most of them was found a green vegetable growth of unicellular plants. However, beneath some pieces the accumulated black dirt shows the fractures to be of more remote origin.

Photographs of the obelisk, taken as soon as the shaft was erected here (see "Egyptian Obelisk," by Gorringe), show numerous pieces broken out of the edges of the shaft, while the lower corners resting on the "crabs" and plinth have scaled off, as nearly all stone does under great pressure. The photographs show also that at least one side of the plinth had flaked before erection here, and all sides of the lower part of the shaft. The hieroglyphics are nearly obliterated on one entire side of the shaft, and their distinctness gone on about two-thirds of another side.

Placing a fragment of the rock under the microscope, portions of it show decided disintegration, parts of the hornblende being broken down and dissolved, while some of the white feldspar is broken into such minute fragments that they exhibit the Brownian movement when placed in water. In the minute crevices can be seen the green cells of vegetable growth, and on either side of the crevice may sometimes be seen, with the microscope, the rosy hue indicating internal strains in the very minute fragments, a slight increase of which would complete the fracture; and it is possible that the growing cells may furnish the necessary strain.

The green cells belong to the lowest class of vegetation, and, containing chlorophyll, are hence not fungoid. One class of the cells is rod-shaped, from two to six micro-millimetres in length, by one and one-half to two in diameter, the sides being straight, with slightly convex ends. On some pieces of rock, these were mostly in single cells, though two and three were connected in a straight line, never branched. These cells were attached to small microscopic fragments in colonies of one to five hundred, apparently by a gelatinous substance, and not easily detached after a moment's immersion in water. These cells require a power of about five hundred to show the cell-wall and the internal spore (?). Up to the present time, I have not been able to find a similar described form.

In addition to the oblong form, another class of round cells, belonging to the genus *Protococcus,* was found on the most disintegrated fragments. Some were round; others were subdividing into twos, quite similar to the figures given in the Botanical Atlas of *Protococcus pluvialis.* So far, I have not found subdivisions of cells into threes and fours, as is found in the *Protoccus viridis* (?), so abundant on the trees in the Central Park near the obelisk. Besides these cells, spores of many other forms of vegetable life were found in abundance.

Dr. N. L. Britton, from his own microscopical observations, confirmed Mr. Dudley's statements as to the nature of the vegetable growth.

President Newberry said that brownstone was upon the whole a poor building stone, and some preservative treatment was most desirable and necessary. To find a substitute would be a good thing, even on æsthetic grounds, as a relief from the monotony of color in our streets. Some varieties were of fair quality, as the Long Meadow stone. A specimen of the Belleville stone had yielded eleven per cent of lime, a soluble constituent. New York had grown up like a mushroom; the buildings were comparatively new, yet were already showing much decay. The marble roof of the Assay office shows well the result of weathering; about one-fourth of an inch of the more soluble material has been removed, while the siliceous and less soluble parts are left projecting. The building of the State Cabinet of Natural History in Albany, only fifty years old, built of Westchester marble, looks as if about to crumble. Many buildings in New York, the Cathedral for example, are of the same stone. In the city, the disintegration of stone work goes on more rapidly because of the greater quantity of sulphur fumes and carbonic acid in the air. But even in the pure air of the country, the limestone and the marble of burial grounds shows the soluble effect of atmospheric gases and water. Siliceous rocks endure better, but no kind of rock can long withstand, in our climate, the combined attack of acidulated water as a physical and chemical agent.

The speaker had no doubt that the obelisk was in a bad condition when it arrived here. Other specimens of Egyptian granite which he had examined showed that after an exposure, even in the dry climate of Egypt, of two or three thousand years the rock becomes shaky. The disintegration is interstitial, and is not very evident to the eye. A fresh or recently quarried specimen of good granite, like the Aberdeen, would not in many years show any such decay as the obelisk has suffered. In the flakes from the obelisk exhibited this evening, the feldspar crystals are broken and the hornblende is quite gone. Some preservative should have been applied as soon as the monolith was erected here.

The President further said that he had knowledge of other processes of preserving stone, and that he had most confidence in a process using paraffine. It was certainly more efficacious than the silica treatment. The name of the substance signified its chemical inertness. It is most unchangeable, yet manageable. It is simple, and easily renewed, and not expensive. Apparently it works no injury to the stone. If it did not deface the stone there could be no reasonable objection to its use. By this process, even if frequent renewal was necessary, the obelisk ought to be preserved indefinitely.

It is a surprise to Americans to find the famous cathedrals and buildings of Europe so much decomposed and subjected to repair. This process would undoubtedly have preserved them in all their original beauty.

MR. R. N. PERLEE said that his house of brown stone had been treated by the paraffine process, greatly to his satisfaction. Now, instead of the steps, railing, etc., becoming permanently soiled and stained, every heavy rain washed the stone as clean as new. His neighbors and friends were pleased with the appearance of the house, and he regarded the process as a first-rate thing; and one that would be greatly beneficial to the city.

MR. CAFFALL said that the expense of treating an ordinary 25 foot brown stone front, with a porch, would be $200 to $300. He did not know how long stone would retain the paraffine compound, certainly for a great length of time. He had word from England that buildings treated sixteen and eighteen years ago, the earliest treated, showed no evidence of loss. Buildings in St. Louis treated in 1879 showed no change. A committee sent to St. Louis to examine the buildings treated by this process, found no instance of failure or dissatisfaction. He could not effectually treat damp surfaces. The steam issuing from the stone or brick formed bubbles in the paraffine, and also kept pores open, thus defeating the purpose of the process.

At Monroe, Louisiana, the rise of water by floods is so great that a large surface of the brick piers of the bridge over the Ouachita River is exposed to floods of rushing water, and to alternate conditions of wet and dry. Four years ago these piers were treated with the paraffine compound, and recently the engineers had written that the condition of the brick and the mortar joints was still satisfactory.

The speaker thought that even if the heat of the sun was sufficient to melt the compound, the effect would only be to drive the fluid deeper into the stone. The evaporating point is about 500° F.

THE PRESIDENT said he had known the temperature of rock to reach 150° F. in the sun; but if the paraffine were melted it would be held in place by capillary force.

DR. DOREMUS expressed himself as a zealous advocate of the treatment of the walls, floors, and ceilings of hospitals, to render them impervious to poisonous emanations from patients.

Dr. Agnew had stated to him that many years ago the north wing of the old New York Hospital (Broadway near Duane st.), had to be abandoned in consequence of the impregnation of its walls with malign influences from the reception of large numbers of sailors and emigrants with "ship fever." Thorough ventilation was tried for several months, with no avail. The walls were then scraped—several of the workmen becoming ill, and three died. Even after re-plastering the walls, this north wing had to be abandoned.

The Lincoln County Hospital in England became saturated with pyæmic and septicæmic poisons. Ventilation, scraping, and re-plastering the walls were tried in vain. Finally the hospital was torn down and rebuilt.

A few years ago the surgical wards of Bellevue Hospital were in a similar condition. Pyæmia would prove fatal to patients who had undergone but trivial surgical operations. This was remedied by elaborate processes of disinfection with chlorine, but it required frequent repetition. Other hospitals in the city have found it necessary to employ chlorine gas as a disinfectant. Even the new New York Hospital has been obliged to purify one of its wards by the liberal generation of this gas.

Now if walls, ceilings and floors can be rendered impervious and non-absorbent, they could then be washed occasionally with dilute solutions of corrosive sublimate, and hospitals, schools, hotels, etc., and all apartments where the sick are confined, could be kept in a healthful condition.

Mr. Caffall stated that after experiments, the authorities of the Broadmoor Criminal Lunatic Asylum for Great Britain, placed the buildings, which held at the time eight hundred patients, in his hands. During several years of work upon it, about 40,000 square yards of interior walls were treated. The late Mr. George Jarvis, who had charge of the buildings, said that this treatment had reduced the death rate among the inmates from the "Broadmoor fever" fifty per cent. Previous to the walls being water-proofed, it was customary after the death of a patient from "Broadmoor fever" to remove from the room the plastering of the walls and ceilings which, however, was not always efficacious.

November 30, 1885.

Stated Meeting.

The President, Dr. J. S. Newberry, in the chair.

Thirty-four persons present.

Mr. P. H. Dudley announced that, in his study of fungi in and upon wood, he had discovered that the mycelium of *these* fungi seems to secrete an acid fluid, able to induce the decomposition of the wood; or, in other words, acts as a ferment to sound tissue. In all cases so far examined, the decay of the wood is rapid or slow according to the amount of mycelium produced.

He also exhibited the growth of a fungus upon a pine plank.

DR. N. L. BRITTON remarked on the occurrence of a schistose series of crystalline rocks in the Adirondacks. It is well exposed in a hill half a mile north of Harriettstown, and near the northern end of the Lower Saranac Lake. The rocks consist of schistose gneiss, with mica and hornblende schists, containing abundant segregated masses of milk-white quartz. The strata have a general east and west strike, and dip 45° to the north. No norite was seen in the immediate vicinity, but it is exposed near Miller's Hotel on the lake, about one mile from the outcrops above described; its relation to these was not made out.

DR. JULIEN said that the borders of the Adirondack region consist very largely of thinly-bedded gneisses, especially the border to the eastward; but the occurrence of such rocks in the midst of the massive rocks was a new fact.

THE PRESIDENT exhibited a photograph of reptilian footprints from the New Jersey Trias. They were found at Milford, Hunterdon Co.

MR. KUNZ exhibited five rubies from Franklin, Macon Co., North Carolina. Their aggregate weight is four carats, and the individual weight is one-fourth of a carat to one and one-fourth carats. In color they vary from pink to a reddish-wine tint. They are all flawed, and of little commercial value. But they are an improvement on all previous finds in this locality, with the exception of those from the Jencks mine, the finest of which are in the possession of Dr. Joseph Leidy.

He also showed an Indian scraper of compact fibrolite, the scraping end polished by use, from Minas Geraes, Brazil. Also an implement, found in an old canal in the City of Mexico, of chalcedony beautifully mottled with chlorite, giving it a rich green color. It measures two inches long, one and one-fourth inches in width, and one-half inch in thickness. A perforation at one end indicates that it was intended to be joined with others.

upon a thong, and used somewhat like a sling-shot; but the end was broken in the drilling.

Mr. Kunz also exhibited and remarked upon several plates of mica found by Mr. Chas. Gavoille in a clay bank, twenty yards from a swamp, in the "French quarter" of Digman township, Pike Co., Penn. These plates measure thirteen by eight inches (325 by 200 mm.), and are pierced with four perfectly round holes, seven mm. in diameter. They are not over one-fourth inch in thickness, and are the finest magnetited muscovite or "picture mica," and evidently served very well the purpose of "mirrors." The original locality of this mica is probably Pennsbury, Chester Co., Pa., and the quality is the finest of this variety.

Plates of mica have been found all through our coast States, and even further west than Ohio. They are sometimes thirteen inches long, ten inches wide, and half an inch thick. Col. C. C. Jones, Jr., describes some specimens which he exhumed in Southern mounds. They were about seven inches long and five inches wide, and in shape were either parallelograms, squares, or elongated hexagons. At each end was a triangular indentation.

These "mirrors" are seldom drilled more than once, and when, as is rarely found, there are four holes, it was probably to prepare them for use as ornaments; perhaps to be worn upon the breast.

President Newberry said that mica had been found in the mounds in Ohio. From a mound in the Cuyahoga Valley, twenty miles south from Cleveland, at least a peck of mica was found in one heap. It contained spangles of magnetite, and had evidently been derived from the Alleghanies, where mica was very extensively mined by the ancient inhabitants of the country. Dr. Julien visited some of these old mica mines, and described them to the Academy. The mica of the mounds seems to have been used for ornament, as pieces are occasionally found cut into definite forms and pierced with holes for attachment.

Galena is often found associated with mica in the mounds of the Mississippi Valley, was probably valued for its brilliancy, and may have been used as a personal ornament or decoration of shrines, as it seems to have never been smelted. It is only known to have been mined by the ancient inhabitants at one locality, and that near Lexington, Ky. A lead vein was here worked for one-fourth of a mile by an open cut; but the old works are overgrown by forest and surmounted by trees, some of which have attained the maximum size of the species in that vicinity, and must be not less than five hundred years old.

The first paper announced for the meeting was read by MR. GEORGE F. KUNZ,

ON METEORIC IRONS.

(1) From Glorieta Mountain, Santa Fé Co., New Mexico.
(2) From Jenny's Creek, Wayne Co., West Virginia.

(Illustrated with specimens.)
(Published in the Annals, Vol. III.)

The second paper was read by MR. B. B. CHAMBERLIN,

MINERALS OF HARLEM AND VICINITY.

(Illustrated with a suite of specimens.)

The time rapidly approaches when it will be said that the mineral localities of New York Island are diminishing in number instead of increasing.

Corlear's Hook (although still appearing on the list in Dana's Mineralogy) long since ceased to be a field of exploration. And other regions of interest, for example, on 23d st., the Kip's Bay Quarries, and adjoining localities on 45th st., and those on 56th, 57th, and 58th streets, near Sixth avenue, have gradually yielded to the demands of the building interests of the city, sending the student to other localities for investigation.

East and west of Central Park, the rock masses are in process of removal, so that this district, and the region northward along the Harlem River, now claim special attention from the local collector. Already points of considerable interest are open to his researches, quite equal to many of those above enumerated in a lower portion of the Island.

Black Tourmalines appear quite plentifully in the neighborhood of Harlem. The specimens are often showy, especially when set in albite or oligoclase, but good terminations are very rare.

In Morningside Park large masses were exposed in blasting operations. These readily disintegrated into black grains, as fine as sand.

Near Mount Morris Park the local mineralogist finds an interesting deposit of this mineral in numerous radiated combinations of acicular crystals.

Mount Morris is a vast deposit of *Garnets*, and extensive beds of the same mineral are found in the rocks adjacent. It is to be regretted that perfect crystals are seldom to be found.

In one locality I have met with *Essonite* or *Cinnamon Stone.* Two or three crystals were of considerable size, with a number of good faces.

The same mineral has been noticed on Tenth avenue, north of Manhattanville, near the site of the Hebrew Orphan Asylum.

Here also appeared masses of *Apatite,* also a few *Beryls,* of a yellow tint. One mass, of a delicate sea-green hue, known as *Aquamarine,* yielded a lapidary two one-carat gems, one of which was recently exhibited before the Academy.

During the past summer, in cutting 100th street through from Third to Lexington avenues, a vein of *Kyanite* was brought to light. The course of the vein is from northeast to southwest, and indications of its presence may be noticed in the streets adjoining. The kyanite occurs in considerable quantity, perhaps the most extensive deposit ever opened on the island.

The typical color of this beautiful mineral is Berlin blue, in varying shades, usually deepest about the centre of the crystal forms or blades. Only a limited portion of the 100th street mineral is of the usual color; the major part is of a green hue, affording handsome cabinet specimens.

It is no easy matter to detect distinct crystals in the deposit, though occasional approximations are noticeable. The imperfect crystalline structure gives the masses a bladed aspect, characteristic of the same mineral at many localities.

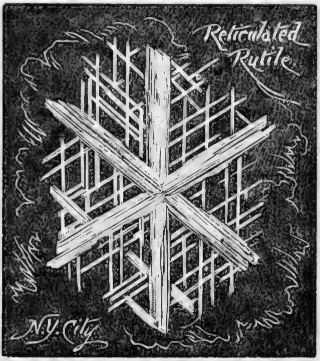
The forked character of the bladed masses permits numerous interstices; these, filled with smoky quartz, add greatly to the beauty of the specimens. Occasionally the effect is enhanced by the presence of garnets of a peculiar light-red color. In two instances the garnets formed masses some twenty inches square.

In near association with the kyanite were the minerals *Scapolite, Albite, Oligoclase,* and *Chlorite.*

Some eight years since, I reported the discovery of that interesting mineral, the *Oxide of Titanium* or *Rutile* in the marble quarries of Morrisania. It is an important name in Dana's list of minerals obtained in the Kingsbridge quarries, which were long since abandoned by workmen.

I had succeeded in finding that mineral in the gneiss formation on Fifth avenue near the 105th street entrance to Central Park. During the past summer, specimens have been secured which, although not showy to the eye, afford, with the aid of a magnifying glass, some interesting features.

The forms presented are those of crystals arranged in lattice-



like combinations somewhat similar to specimens from North Carolina, known as *Reticulated Rutile.* Two of our New York

specimens are wheel-like figures, similar to the crystallographic structure of a snow-flake.

Six stout crystals form the axes of the structure, across which are symmetrically arranged more slender crystals at angles of 60°.

The color of the crystals, after the removal of the outer crust by an acid, is blood-red.

The associated minerals are chlorite, in radiated globes, albite, oligoclase, and scapolite. A handsome *Brown Spar* and a zeolite, thought to be *Harringtonite,* have also been noticed; also two or three small but highly-modified crystals of a light-yellow *Sphene.*

Farther up the avenue appears that peculiar variety of chlorite known as *Jefferisite.* Interesting specimens are those where the Jefferisite appears as a coating to trilateral or wedge-shaped fragments of quartz. I have thought these singular forms due to cavities in crystallized albite from which they have been removed.

In Morningside Park may be found a broad vein of pure milky *Quartz,* much of which is laminated—a somewhat unusual form of this mineral.

On Washington Heights, near High Bridge, laminated quartz terminates in splintering masses of loosely-aggregated grains, reminding one of icicles, or finials to a Gothic tower. The quartz occasionally presents highly polished surfaces produced by glacial action.

Along the east bank of the Harlem River may be noticed fragments of *Bog-iron ore,* much of which is highly iridescent. This is on Dana's list of Harlem minerals.

In conclusion, reference may be made to the mineralogical character of the ridge directly east of the Harlem River.

The formation is a regularly laminated gneiss furnishing excellent building material, sometimes of much beauty due to its distinct shades. It is noted for the absence of the potash feldspar, its place being supplied by a whitish variety, probably albitic. Further than this, the formation is devoid of special interest to the mineralogist. Nor do the excavations along the line of the new aqueduct for a number of miles furnish material worthy of an extended notice.

President Newberry exhibited and commented upon three interesting pamphlets which he had recently received. They are (1) "On Luminiferous Ether," by Professor De Volsen Wood, of the Stevens Institute; (2) "On the Denudation of the two Americas," by T. Mellard Reade, of Liverpool; (3) "On the Geological Age of the North Atlantic Ocean," by Professor Edward Hull, Director of the Geological Survey of Ireland.

The first paper gives an interesting summary of what is known and believed in regard to that real but intangible medium through the undulations of which light traverses space.

The second paper is an attempt to estimate the annual erosion over the surface of the two American continents by atmospheric agencies. Compiling all the observations made, Mr. Reade's conclusion is that rain and rivers remove, in mechanical suspension, one foot of the surface in 6,000 years. But to this measure of denudation, which is based upon the sediment transported by different streams, he adds an estimate of the matter carried away in chemical solution, which he supposes to be about one-third of that transported in suspension. Combining both, he estimates that for the entire continents about one foot would be removed from the surface in 4,500 years. However, it should be said that, in the better watered portions, where the agents of erosion are more active, one foot is removed from the surface in about one-half that time, or from 1,800 to 2,500 years.

In Professor Hull's article, which is printed in the *Transactions of the Royal Geological Society of Ireland*, 1885, an effort is made to trace the origin of many of the sedimentary rocks of Europe and North America to the erosion of a broad continent, which, in his opinion, formerly occupied the greater part of the area of the North Atlantic Ocean, and from which eroded material was carried into the sea basins, which, he imagines, then occupied the places of Europe and eastern North America.

To sustain his theory, he quotes the facts reported by many geologists, that the mechanical sediments—conglomerates, sandstones, and shales—of the Palæozoic series, which have, along the Alleghany belt, a thickness of 20,000 feet, diminish to 4,000 feet in the valley of the Mississippi.

A better acquaintance with American geology would have saved Professor Hull from an error into which he has here fallen. It is true that the strata which have been derived from the erosion of the land do increase from the center of the Mississippi valley to the Alleghany belt; but there they are at their maximum, because this was their place of origin. Among these strata may be mentioned the "Seral conglomorate" of Rogers ("Millstone grit"), which is at some localities in Pennsylvania 1,000 feet in thickness, and some of its pebbles are six inches or more in diameter—really boulders, such as could not have been transported far from their place of origin, and could certainly not have been derived from any mid-Alantic continent. The Oriskany sandstone, the Medina and the Potsdam, which are the shore deposits and bases of the Devonian, and Upper and Lower Silurian systems, are nearly as thick and coarse along the western flank of the Blue Ridge, the old land of the Alleghany belt. But the representatives of the same strata in New England are much thinner, and generally finer, though deposited nearer to the imaginary Atlantis.

The fact is that a belt of high land occupied in part the place of the Alleghanies from Archæan times. From its surface, as we know by indisputable evidence, not less than four or five miles of material have been removed, and by drainage lines and the advance and recession of shore waves, spread inland toward the center of the Mississippi valley. The quartz veins of the eroded metamorphic rocks furnished the conglomerates and the sandstones; the argillites and schists made the shales of each system; and these sheets of land-wash diminish in thickness as we recede from their place of origin. So the Canadian Highlands, with the Adirondacks and Lake Superior region, formed another land area in Palæozoic times, from which the wash was spread southward, in sheets of diminishing thickness. The same is true of the old land of the far west. The Potsdam sandstone is as thick and coarse around the Black Hills and along the flanks of the Rocky Mountains and the Wasatch, as anywhere in Canada, New York, or Virginia.

European geologists are best qualified to discuss the application of Professor Hull's theory to European geology; but speaking only from my own knowledge of American geology, I can say that the facts here not only do not sustain, but positively disprove it. It would be only necessary for a geologist as sagacious, experienced, and honest as Professor Hull, to make even a hurried reconnaissance of the structure of eastern North America to be convinced, and to confess that it here finds no support.

The recent earthquake waves felt on the Pacific coast, and the remarkably high tide upon the Atlantic coast, were the subject of discussion by PROF. MARTIN, PROF. TROWBRIDGE, and DR. JULIEN.

December 7, 1885.

REGULAR BUSINESS MEETING.

The President, DR. J. S. NEWBERRY, in the Chair.

Forty persons present.

PROF. LAZARUS FLETCHER, Curator of the Mineralogical Department of the British Museum, and PROF. VALENTINE BALL, Director of the Science and Art Museum, Dublin, were elected Corresponding Members.

In behalf of MR. G. F. KUNZ, MR. B. B. CHAMBERLIN presented for the notice of the Academy a large almandine garnet, seven inches in diameter, and nine and one-half pounds weight, found during the past week in an excavation on 35th street, between Broadway and Seventh avenue. MR. KUNZ regarded the crystal as the largest of the kind ever reported from the Island. It is in good condition, showing twenty faces of the trapezohedron and nearly half as many faces of the dodecahedron. The combination of the two forms gives it additional interest. The edges of the rhombic faces are truncated. The general color of the garnet is a reddish brown modified by olive-green spots of chlorite. The fractured portion of the crystal shows dodecahedral cleavage.

He also announced for MR. KUNZ that Herderite had been found at a new locality in Maine, a place known as Morrow Ledge, near the Hatch farm, Auburn, Maine, where fine colored tourmalines were found two years ago. With the Herderite were found large quantities of lepidolite, amblygonite, Cookeite, and some colored tourmalines of little value. Of the crystals exhibited, one measures 15 mm. in length by 8.5 mm. in diameter. This has a light-yellow color, transparent in parts, and with good brilliant faces. Another crystal, quite opaque, measures 20 mm. by 16 mm., and has imbedded in it a quartz crystal and a small piece of transparent green tourmaline.

MR. KUNZ also announced by MR. CHAMBERLIN the discovery of a new locality for prehnite. Fine distinct primitive crystals measuring 5 mm. on a face were found near the city of Auburn, Maine. The mineral was first identified at this locality by Mr. N. H. Perry, and procured later by Mr. S. F. Lamb.

DR. CHARLES E. MOLDENKE read a paper on

THE EGYPTIAN ORIGIN OF OUR ALPHABET.

Many strange and false notions have been entertained about the origin of our modern arts and sciences; and these notions have become stereotyped in our educational books, and are disseminated among all classes of society. It was the work of Egyptology to revolutionize many of our conceptions, and to destroy some of the pet ideas of modern times. Too little attention had been given to the many passages of ancient authors, paying their tribute to Egypt as the source of all learning; or if noted, they could not be established, for want of proof. That period of guess-work and arbitrary judgment has happily passed away, and a new era has begun since the discovery of the key to the Egyptian language by Champollion, and its development by Lepsius. We now know that we do not owe our mathematics and our decimal system to Greek or Chaldee sages; that our science of medicine does not take its beginning with Hippocrates or Galen, but with old Egyptian doctors, pre-eminently with Nebsecht, the great physician at the time of Moses at the court of Ramses II.; that the first principles of architecture have come down to us from Egypt by way of Athens and Rome; that the art of war does not date back only to an Alexander or Julius Cæsar, but to a Thothmes III. and Ramses II.; that the invention of glass is not due to the Phœnicians, but to the experiments of the Egyptians; and that most of our so-called comforts of life have their starting-point in Egypt, and have only undergone development and improvement in the long journey of thousands of years till our day. All this should make us heartily grateful to the inhabitants of the Nile valley; but we should also bless them for the greatest gift they have bequeathed to us, for one that cannot be outweighed by all the others—the gift of written language. This greatest of blessings—the means of exhibiting the spoken word to the eye, the means of recording our ideas for posterity—we owe to the ancestors of a people now despised, to the forefathers of the wretched Copts and Fellaheen of Egypt.

We can trace our alphabet, as we still use it every day of our lives, to its very first origin; and can lead it to a point where there is but one further step possible: to *spoken* language. Our encyclopædias contain so many false and absurd statements with regard to the origin of the alphabet, mingling truth and fiction, that in this they are, for the most part, untrustworthy authorities. The alphabet is generally put down as a Phœnician invention, which is *absolutely* wrong. To this Shemitic people the invention of many things has been ascribed, without any satisfactory reason or proof. They merit our thanks only so far as they were the conservers of what they themselves received.

The history of our alphabet is the history of civilization. With the introduction of letters and the means of fixing words on stone, paper, or leather, there began a more rapid development of the faculties of man, and the consequent changes in the home and the state. As every invention, though excellent and perfect at first sight, admits of improvement, so was this the case with our written language. When looking at the definite form of our present letters, we should see in them the result of a gradual development, the product of many changes. The first act of a man in the morning and the last in the evening is to *see*, to see a picture. It is, therefore, not strange that the first endeavors of man to convey a thought to another should be by the use of a picture. Such was the primitive writing of our Indians, the Mexicans, Chinese, Assyrians, and Egyptians. It is only a picture that we now see in our letters, but that picture represents a *sound*. The first inventors of our letters could have had no pictures at their disposal, beyond what they really saw in nature; therefore, the first means of conveying thought in writing must have been pictures of natural objects. Tradition corroborates this statement; and however little tradition may be used in any scientific research, yet it helps greatly when it is not made the basis of investigation. This tradition is given in the names of the Hebrew letters, for instance, A or Aleph is "ox"; B or Beth is "house"; G (= our C) or Gimel is "camel"; all of which refer the letter back to a picture. It would, however, be totally misleading to adopt the other part of this tradition, that the letters must originally have had the forms of the objects after which they were named; that is, that because A is "an ox," N "a fish," P "a mouth," S "a tooth," the letters A, N, P, and S must have been at first expressed by the pictures of an ox, fish, mouth, and tooth. The adoption of this tradition has, until quite recently, proved the stumbling-block of all our dictionaries and encyclopædias. By accepting this, we would not be able to advance one step further in our investigation, as no such original pictures have ever been found.

It is a strange coincidence that the words expressing the act of "making letters" denote, in the first place, "to scrape or dig, to chisel or draw in outline." Thus the Latin *scribo*, the Greek *γράφω* (*grapho*), the Hebrew ספר (*safar*), the Egyptian *chet*, all of which mean to write, have for their primary meaning "to scrape." Our English "to write" has the same primary meaning, coming from the Anglo-Saxon *wrîtan*. In the Runes of our forefathers, we find the word *rita* ("to write") interchanges with *rista* (the modern German *ritzen*), "to scrape or scratch," pointing out the manner in which the Runes or letters were written. While our ancestors scratched lines and curves, the ancient Egyptians took up the chisel and engraved pictures in stone. This points directly to inscriptions in stone as the first in use, and the oldest we know for certain are the Hieroglyphical Inscriptions of Egypt.

Running parallel with the tradition that Cadmus (also Cecrops, Linus, Palamedes) and Simonides were inventors of the Greek alphabet, and that it had its origin from the Phœnicians, is a tradition of ancient writers which claims that the alphabet was of Egyptian origin. Sanchoniathon (Eusebius, "Prep. Ev.," 1, 10, p. 22), the Phœnician historian, says that Thoth, the Egyptian Mercury, was the first who instructed the Phœnicians in "the art of painting the articulations of the human voice." Plato ("Phædrus," 59), Diodorus (1, 69), Plutarch ("Quest. conv.," IX., 3), and Aulus Gellius ("Noct. Att.") also mention this tradition; while Tacitus says in his "Annals" (XI., 14): "The Egyptians were the first who represented the perceptions of the mind by the figures of animals (these, the most ancient monuments of human memory imprinted on stone, are still to be seen), and thus proclaimed themselves as inventors of the alphabet; thereupon the Phœnicians, who excelled on the ocean, introduced it into Greece, and gained glory just as though they had invented what they merely received from others." It is strange that this passage never received the attention of investigators on the origin of our alphabet, as it might have turned their eyes in the true direction. The latest testimony is that of an Arabic writer, Ibn 'Abi Jaqûb, who wrote the first Arabic history of literature (987 A.D.), and who says that the Greeks received only sixteen letters *min misri*, i. e., from *Egypt*, and that eight new letters were added in Greece. What tradition hinted at and surmised, it was the work of Egyptology to prove and establish beyond a doubt.

Picture-writing need not necessarily include *phonetic* writing. For instance, our Indians drew pictures which gave the *sense* of their writing; but the Egyptians gave their pictures exact syllables or words. They soon found, however, that such a writing would require too many pictures, so they selected twenty-seven (or, if we count the variants, thirty-three) of these pictures to represent simple letters. This was a step whose great importance in the history of writing can now be fully realized. But they also retained their syllabic writing (*i. e.*, they could write a word *rud*, "to blossom," with a syllable-sign *rud*, or spell it out in simple letters, r-u-d). As they conceived their writing to be an invention of the gods, and therefore of itself divine, they engraved these pictures on stone, or used them on papyrus only in the Book of the Dead. For business and secular purposes, however, they drew these pictures on paper or leather either in outline or very much abbreviated. It was in this form, known as the Hieratic, that other than African nations saw the Egyptian writing, although they knew from report that the Egyptians wrote in pictures, and that those Hieratic signs had originally been pictures. That other nations must have gained their letters from Egypt seems to be proved by an inscription of Ramses II., recording the treaty between him and the Hittites, and the fact that the Hittites (mentioned so frequently in the Bible) were to engrave the same inscription in their language on a tablet of silver. Many monuments in Æthiopia (Nubia) have been discovered with Egyptian letters, but not Egyptian words, proving that these nations wrote words of their language in Egyptian characters, as the Jews nowadays frequently write their English or German in Hebrew letters. The commerce of Egypt naturally brought it in close connection with the Shemitic tribes, and the Shemites thus had opportunity to see Egyptian writing. Now the Egyptians were accustomed to spell foreign Shemitic names in pure letters, which they could alone have taught the Phœnicians, as the Hieroglyphs were too sacred to be divulged, and of these letters the Phœnicians adopted twenty-two. This may have taken place about 1600 B.C., at any rate, before the time of Moses. But the Phœnicians advanced to a position superior to the Egyptians, for, while the latter had signs for letters *and* syllables, the Phœnicians had only letters. Their letters had consequently also the same sound as the Egyptian letters. As far as we know, the Egyptians had no names for their letters, but only the sound. The Phœnicians, knowing that what they now had were really pictures, and wishing to lay stress on this fact, that is, to express in the name of the letter its sound and its picture at the same time, gave names of objects to their letters. The Egyptian form of their letter could not give them a clue as to how the picture looked originally, and had they known it, they could not have called their letter after it. For instance, the "eagle" (or A) is called נשׁר (*nêsher*) or פרס (*pêres*) in Hebrew; but how could they have called their letter A by a word beginning with an N or a P; or the "snake" (or F) is נחשׁ (*nachash*) in Hebrew, thus beginning with an N, while the letter is F. But they did *not* know the original pictures, and consequently gave names to each letter according to their fancy. The A they called *aleph*, "ox;" the B, *béth*, "house;" the G, *gimel*, "camel;" the D, *dâleth*, "door," etc. These names they handed down to the Greeks and the Copts, while the Romans and all succeeding nationalities rectified this blunder by only calling each letter by its sound: a, be, ce, de, etc. A detailed description of the Phœnician alphabets is not necessary for our purposes here. Suffice it to say that a few years ago a link between the Phœnician and Egyptian was found in the inscription of Mesha, King of Moab, who is mentioned in the Bible (2 Kings iii. 4). This inscription, though not purely Phœnician, presents the oldest form of the Shemitic alphabet now existing. Although it is about seven hundred years younger than the probable introduction of the Egyptian alphabet into Phœnicia, still the similarity between the two is very striking, as well as the gradual development of the letters in the Phœnician stem itself. As it seems, no fixed laws governs the changes in the letters, but the general tendency is to simplify letters by leaving out lines or rounding off corners.

The Phœnicians soon spread this godsend among the nations of the Mediterranean Sea. It reached the Greeks and Latins at about the same time. The Greeks adopted the alphabet in the very same order as the Phœnicians. Still, as the Greeks had some sounds that were wanting in the Phœnician, and found many in the Phœnician which they did not have, they took the *forms* of the letters, but gave to some of them a different sound. Thus the fifth letter was H in Egyptian and Hebrew, while the Greeks turned it into E; the sixth became a digamma, and was afterwards dropped; the eighth, CH in the Egyptian and Hebrew, a very rough aspirate, was used to represent the heavy long e (or *η*, *êta*); the fifteenth, S in Egyptian and Hebrew, became a *Ξ* (*xi*), our X, since the Greeks found so many S-sounds in the Phœnician that they could not make use of all; the sixteenth, the strange Shemitic guttural sound, resembling somewhat our short o, became O; the eighteenth, a TZ in Egyptian and Hebrew, was dropped, while the nineteenth, K or Q, in Egyptian and Hebrew, was only used in ancient inscriptions. The Greeks then added *Υ*, *Φ*, *X*, *Ψ*, *Ω* (*upsilon*, *phi*, *chi*, *psi*, and *omega*). The *upsilon*, as is now conceded by all philologists, is the only pure Greek letter, while the rest are double or compound letters: phi = P + H, chi = K + H, psi = P + S, omega = O + O.

The result of our investigation so far is that the order of the primitive alphabet is retained, the forms of the letters remain, while some sounds change. When we pass to the Latin, we find a few more changes. While the ancient inhabitants of Italy seem to have received their alphabet direct from the Phœnicians, still later in Rome, Greek influence helped definitely to form the letters. The Etruscan, Oscan, Umbrian, and Faliscan letters read from right to left, which points to an early reception from abroad, just as in ancient Greek inscriptions the lines read alternately from right to left and from left to right; viz., first line, right to left; second line, left to right; third line, right to left, etc. (called the *βουστροφηδόν*, *boustrophêdon*, writing, *i. e.*, turning like oxen in ploughing). The third letter, the Greek G akin to K, was changed into C (with pronunciation of K); the sixth, the Egyptian F, returns to that sound. With the seventh letter, we find a great and only change in our alphabet. In all former alphabets, we found a Z in this place, also in the old Latin and Oscan dialects; but in Latin this letter is dropped here, and placed at the end of the list, while the letter G is put in its stead about 520 A.U.C. (= 231 B.C.). The eighth letter loses still more of its original force, and becomes a weak aspirate, our H (though the fifth Egyptian and Hebrew letters represented that sound, of which the Greeks, as we saw, made an E); the ninth is dropped, as there was no such sound in Latin, while if we had lived then, we should have adopted it for our TH; the nineteenth, the Egyptian, Hebrew, and Greek K or Q, became Q, and the Greek additional letter *upsilon* became Y, and, omitting the vertical line, simply V, which was split up later into U and V. The Greek χ (*chi*), which sound the Latins did not need, became Latin X, representing the same sound as the fifteenth Greek letter. The Greek sign for this letter (Ξ) must have offended the Latin eye, as the three horizontal lines were not joined, and therefore they took some other letter of the Greek alphabet. The Z the Latins placed at the end of the alphabet for the sake of keeping the old arrangement intact, which, by the addition of the G in the middle, necessitated their placing Z at the end. With the Latin alphabet, our investigation ends, as we have virtually come back to it, having only added J, an outgrowth of I, and W, which is a double V or U.

While the questions as to the age of mankind and the origin of language still remain unanswered, the origin of our written language has been established. About 1600 B.C., a new spirit of enterprise dawned on the shores of the Mediterranean Sea by the exertions of a Shemitic race; and the "best thing that Egypt gained and created for itself came as a legacy to a new world of open disposition, and free of prejudice. When the cry resounded 'Cadmus has come!' when the letters began their journey from East to West, over land and water, then first was the wall torn down which separated the nations, and had made knowledge the prerogative of a certain class." And the letters became a word, and the word governs the world.

NOTES.

Whatever has been written or said about the *arrangement* of the letters is only based on theories, and cannot be touched upon here. The following may serve as explanation to the chart:

1st letter: Egyptian "eagle" = A; becomes a *consonant* in Phœn., Aram., and Hebrew, א; changes to vowel in Greek, Coptic, Latin, and English. Pronunciation the same throughout (in Shemitic with more guttural force).

2d letter: Egypt. unknown kind of "bird," really a syllabic sign = ba (symbol of the human soul), but also used as letter b = B; obtains in the Shemitic pronunciation of b or bh, בּב; Greek, Coptic, Latin, and English have pronunciation B.

3d letter: Egypt. "vessel with handle" = K or G; obtains in Shemitic pronunciation g or gh, גּג; Greek and Coptic g; Latin C with K sound; English C (= S or K).

4th letter: Egypt. "palm of hand" = D; obtains in Shemitic pronunciation d or dh, דּד; Greek–English D.

5th letter: Egypt. "fence or hedge" = H; in Shemitic h or silent h, הּה; Greek–English E (by dropping the aspirate).

6th letter: Egypt. "snake" = F; in Shemitic like our W, ו, and servile letter for vowels ô and û וֹוּ; in Greek a digamma (in ancient inscriptions only); Coptic F (going back to original Hierogl.); Latin, English F.

7th letter: Egypt. "newly-fledged bird," really syllabic sign for *dza* = Z (= dz); in Shemitic, z, ז; Greek, Coptic, and old Latin Z; is dropped in Latin in this place, and G put in its place (related to C); English G.

8th letter: Egypt. "sieve" = CH (pronounced like Greek and German *ch*, with rough guttural sound); remains ch in Shemitic, ח; Greek makes of it a long, heavy ê (= our long a); Coptic takes the Greek ê, and also goes back to the Hieroglyphic to get its ch sound; Latin goes back to the original aspirate sound, and makes of it our H; English H. This letter was used by the Greeks for another purpose. By taking the first half, and rounding the corner, they received their rough breathing ʽ, and by taking the other half, they obtained the smooth breathing ’, that is, our H and our silent H.

9th letter: Egypt. "pair of tongs (?)"=TH; in Shemitic almost like our th, ט; Greek and Coptic and Old Latin th; dropped in Latin and English.

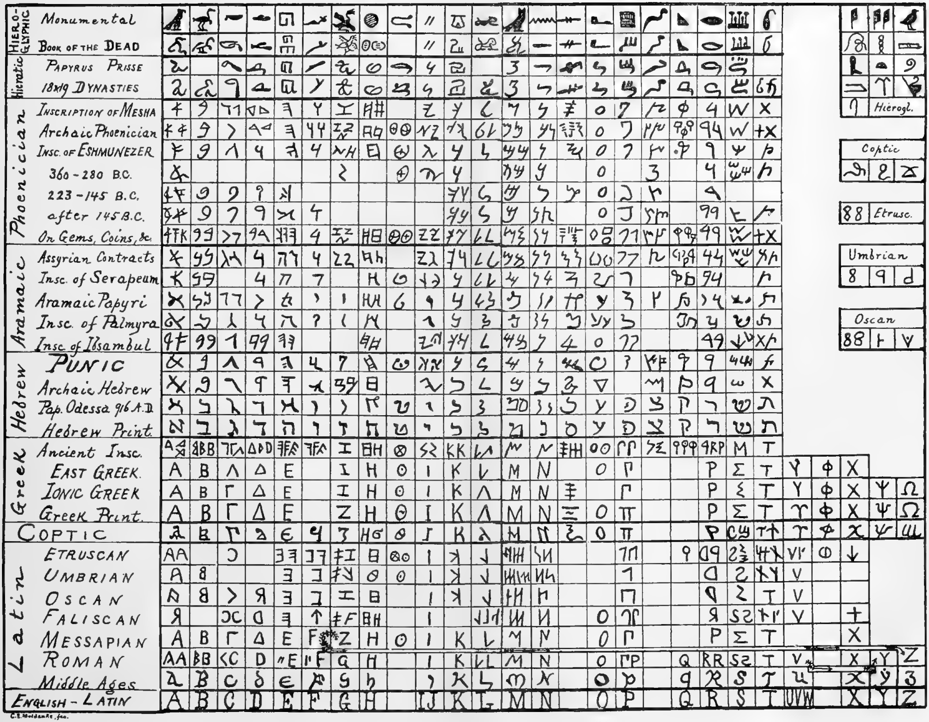
10th letter: Egypt. "two lines"=I; becomes a consonant in the Shemitic, י, and servile letter for long i; a vowel in Greek–English. English adds J: I before consonants, J before vowels.

11th letter: Egypt. "basket"=K; in Shemitic K or Kh ךכּכ; Greek–English K.

12th letter: Egypt. "lion"=L ל; remains L throughout.

13th letter: Egypt. "owl" (bird of death)=M םמ; remains M throughout.
14th letter: Egypt. "undulating surface of water"=N ןנ; remains N throughout.
15th letter: Egypt. "bolt of door"=S; in Shemitic sharp s ס; Greek changed it into a KS=our X, while the *form* of this letter does not occur after that.
16th letter: Egypt. "arm"=peculiar guttural sound only found in the Shemitic; Shemitic retains it ע; Greek–English make of it an O as nearest pronunciation.
17th letter: Egypt. "square or window"=P; in Shemitic p or ph (=f) ףפּפ; Greek–English P.
18th letter: Egypt. "snake"=TZ; Shemitic Z (=tz) ץצ; dropped in later Greek–English.
19th letter: Egypt. "triangle"=K or Q; Shemitic q ק; old Greek q; dropped in Coptic; old Latin q; by shortening vertical line Latin Q, English Q.
20th letter: Egypt. "mouth"=R ר; remains R throughout.
21st letter: Egypt. "meadow with trees"=SH; in Shemitic has pronunciation of Sh or S according to the dot above the letter (dot at beginning שׁ=sh, at end שׂ=s); remains S from Greek–English.
22d letter: Egypt. "bag (?)"=T or TH; in Shemitic t or th תּת; Greek T; Coptic, from Greek T, and also going back to Hierogl. gets a new letter for TH; Latin to English T.
23d letter: begins with Greek Y; Coptic Y; changes in Latin to V=V before vowels, U before consonant; English adds W= double V or U.
24th letter: Greek *Φ* phi=PH, only in Greek, Coptic, and old Latin.
25th letter: Greek *X* chi=CH (=German ch); becomes Latin X (our X) for reasons stated above; English X.
26th letter: Latin and English Y coming out of Greek upsilon which thus gives rise to four English letters: U V W and Y.
27th letter: Latin Z, put at end of alphabet from place No. 7, for reasons stated above; English Z.

Besides this the Egyptian has some more letters, really variants (reading on the chart from left to right): a; î; u; û; h; sh; b; t; u; m; m; n; s. The Coptic: ch; h; dg (pronounced like gi in giant). Etruscan: f. Umbrian: f; rs; and sh, s or z. Oscan: f; i; uʿ or o. Greek: psi and omega. The third kind of Egyptian writing, Demotic, is not mentioned here, as it originated first about 700 B.C., and therefore did not play any important part in the development of our alphabet. The Coptic, the fourth kind of Egypt writing, took its letters from Greece, and some others,



C. E. Moldenke, fec.

mentioned above, from the original hieroglyphs through the Demotic.

The subject was discussed by PROF. H. C. BOLTON, DR. L. SCHOENEY, the PRESIDENT, and the AUTHOR of the paper.

December 14, 1885.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

A large audience present, in the west lecture room of the Library Building, Columbia College.

The first lecture of the Popular Lecture Course was delivered by PROF. EDWARD D. COPE.

Subject: THE GENEALOGY OF THE MAMMALIA.

(Illustrated with diagrams and charts.)

December 21st, 1885.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Seventy-two persons present.

The following papers were read by title.

I. A REVIEW OF THE GENERA AND SPECIES OF DIODONTIDÆ FOUND IN AMERICAN SEAS. By CARL H. EIGENMAN.

II. A REVIEW OF THE NORTH AMERICAN SPECIES OF PETROMYZONTIDÆ. By DAVID S. JORDAN and M. W. FORDICE.

(Published in the Annals, vol. III., Nos. 9 and 10).

Professor WILLIAM D. MARKS, of Philadelphia, Pa., read a paper entitled

A REVIEW OF DYNAMIC ELECTRICITY.

Electricity can at our will be converted into heat, light, and motive power. With all these capabilities it lends itself in a wonderful way to the convenience of man, because of its ability to be led to the exact point at which we desire to use it, and can then be used at will in large or small quantities.

In short it possesses—
Facility of distribution;
Indefinitely great divisibility according to need; and
The ability to concentrate great power in a very small space.

I must limit myself, because of the brief time allotted, to the consideration of a small part of my subject, and even in this I will still further limit myself to phenomena occurring on so considerable a scale as to be generally called engineering problems.

I will particularly call your attention to the conversion and reconversion of electrical energy into other forms of energy, in three ways.

First.—The conversion of heat into electrical energy.

Second.—The conversion of electrical energy into light.

Third.—The conversion of electrical energy into mechanical energy.

The Conversion of Heat into Electrical Power.

The direct conversion of heat into electrical energy, has already had a partially successful, but not economical solution in Clamond's stoves.

According to Cabanellas, a Clamond's stove consisting of 6,000 elements and burning 22 lbs. of coke per hour, will give a current of 218 volts difference of potential, and 7 amperes.

Cabanellas also states that the amount of light obtained was equal to about 560 standard English candles.

This would give us nearly 26 candles per pound of coke. As we shall presently see, this is a result much less economical of fuel than can be obtained by the use of an engine and dynamo, under very unfavorable circumstances. The liability to derangement, and the first cost of Clamond's Pile, have prevented it from becoming commercially successful.

Those of you who are familiar with electrical terms will pardon me if I devote a small portion of our time to the endeavor to make their meaning clear to those who have given little time or thought to them, but are familiar with purely mechanical ideas.

The ohm, volt, and ampere are the practical British Association units used by electricians.

The legal ohm is the resistance of a column of mercury one square millimetre in cross section, and 106 centimetres in length, at the temperature of melting ice.

Ohm's law is

$$\text{Intensity of Current} = \frac{\text{Diff. of Potential}}{\text{Resistance}}, \text{or } I = \frac{E}{R},$$

from which you at once see that the resistance equals the ratio between the electro-motive force lost in the circuit, and the intensity of the current.

This is a constant for any solid so long as its form and temperature are not changed.

The volt, and ampere are more difficult to define, and perhaps I can best make their meaning clear by making use of analogous hydraulic formulæ.

Understand me, this is only a case of analogy. I do not say that electricity is a fluid, nor would I like to say that there is a current of electricity, or that it flows one way or the other.

The volt may be said to represent the pressure or head of the assumed current of electricity, and the ampere to represent the intensity or weight of the current passing in one second. Lord Rayleigh has carefully determined the weight of silver precipitated from a solution of nitrate of silver by one ampere. It is 0.06708 grammes per minute, or 4.0248 grammes per hour.

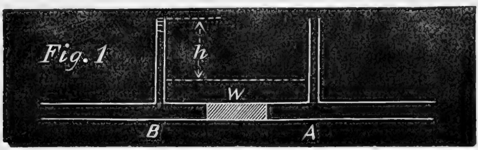


Fig. 1

Referring to Fig. 1, if W equals the weight of water that passes the point A in a pipe, in one second, and *h* the loss of head, we have for the work done in one second, W *h* foot lbs.

Again, if I represents the intensity of a current passing the point A in a second, and E the difference of potential in volts between B and A, we have for the work done in one second I E volt, amperes, or Watts. If we divide W *h* by 550 ft. lbs. we obtain the horse-power.

In the case of the pipe, if it were level, the loss of work would be due to friction, and transformed into heat.

$$\text{Thus } h=\frac{v^2}{2g} \text{ and } W\,h=\frac{W\,v^2}{2g}=\frac{M\,v^2}{2}.$$

Joule has shown us by experiment that the heating of a wire conductor is proportional to $I^2\,R=IE=\frac{E^2}{R}$, or using the analagous hydraulic formula, the heating is, $W^2\times\frac{h}{W}=W\,h=\frac{h^2}{\frac{h}{W}}$

Again, $\frac{I\,E}{9.81}=$ work per second in kilogrammetres, but an

English horse-power equals 76.04 kilogrammetres per second, and, therefore, one horse-power$=\frac{IE}{745.9}$. Returning again to the ohm, we have $R=\frac{E}{I}$. That is, the resistance is the loss of electromotive force per second and per unit of intensity which an electrical current experiences when passing along a conductor. If this conductor is the standard quick-silver column, R=1 ohm.

In an analogous manner we could say of a horizontal pipe conveying water, that the resistance is the loss of head per pound, and per second, when passing through the pipe.

The resistance of the various materials used as conductors for the electrical current has been repeatedly and carefully determined.

I trust I have established a clear and cordial understanding of the terms which I shall need to use.

By the electro-motive force in volts, I mean something similar to the head of water in feet.

By the intensity of a current in amperes, I mean something similar to weight of water passing in pounds per second.

By the resistance in ohms, I mean something similar to the loss of head of water per pound and per second.

The dynamo-electric machine is the newest, and the most perfect of machines for the transformation of energy from one form to another. Like the turbine, its efficiency has been proved so great as to preclude all hope of further increase of practical value. Its cost may be reduced by improved processes of the machine shop, we cannot do more.

One reason for this rapid perfecting lies in the apparent obscurity of electrical phenomena, which has had the effect of repelling all but subtle and acute minds from their study. The right end of the thread once seized by such minds, they have followed the clue with such rapidity and thoroughness of apprehension as to leave nothing more for us to accomplish.

The recent experiments of the Franklin Institute upon the dynamos of Weston and Edison have set the seal of absolute measurement, with as great exactitude as we can hope to reach, upon the ability of these machines to transform mechanical work into electrical work.

Of the five dynamo-electric machines which successfully withstood the severe conditions of the code, Weston's mammoth incandescent lamp machine, of a rated capacity of 125 amperes and 160 volts, returned, as an average of four tests, in the form of electrical energy $96\frac{56}{100}$ per cent of the mechanical power used to drive it. $89\frac{37}{100}$ per cent of the mechanical power was available as electrical energy in the external circuit.

Of the total mechanical power applied, about one per cent was lost in friction of the armature shaft, and resistance of the air to its rapid revolution.

Two and one-half per cent only remains to be accounted for, and were presumably lost in the form of heat and eddy currents.

Every precaution was taken to avoid results which would not appear in every-day use, and all of the machines were run under full load for ten hours before the measurements began, and so were at as high a temperature as would be reached in actual practice with the same atmospheric temperature. The performance of this particular machine only exceeded the least efficient of the machines tested by $2\frac{1}{10}$ per cent total efficiency.

These results show that this high efficiency is not extraordinary, but is, and should be attained by all dynamo makers building similar types.

In the case of the Weston (7 M.) dynamo, already specified, the power applied was distributed as follows in the first full load test:

Friction and wind resistance of armature.	.0106	Total.
Electrical energy lost as heat in armature.	.0559	"
" " " in creating field....	.0170	"
" " " in external circuit..	.8992	"
Total of power accounted for.... ...	.9827	
Electrical energy lost in eddy currents, heat, and otherwise unaccounted for...	.0173	
Total power as per dynamometer.......	1.0000	

This differs from the average already quoted, because slight variations of the conditions would cause any of the machines to vary somewhat in their percentages.

The greatest cause of uncertainty in experiments heretofore made upon the transformation of mechanical power, has been our lack of certainty of accuracy in the measurements of the mechanical power driving the machine. The dynamometer must sum up the whole power yielded to the dynamo with as great accuracy as is possible for all other measurements in part.

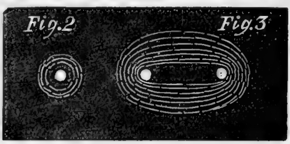
This dynamometer must be capable of being standardized by absolute measurement, and, after being standardized, the machines to be tested must be able to be attached to it or removed from it without altering the centres or adjustments of the dynamometer. It must be of great sensitiveness to small variations of load while measuring large amounts of power with great steadiness.

All of these conditions were fulfilled by the dynamometer invented by Mr. Wm. P. Tatham, President of the Franklin Institute. Its extreme capacity is 100 horse-power, and yet, while making 1,040 revolutions per minute, carrying a load of 29 horse-power, it was possible to measure with certainty the difference of power required by an Edison volt meter requiring $\frac{2}{10}$ of a horse-power. It announced at once the making and breaking of the circuit of this volt meter, measuring the work lost in it with accuracy. Still other tests showed its capability to promptly register small changes of power while carrying great loads, and proved that the slight and rapid jar of the parts, due to a high speed, increased its sensitiveness of measurement.

Finally, this dynamometer was calibrated by the agitation of water, heating something over 5 tons of water through 15.5° centigrade, giving, as the mechanical equivalent of heat, 772.81 foot lbs. per British unit of heat (see report).

While little can be claimed in the way of originality of apparatus or methods used in the electrical measurements of these tests, I trust that an examination of the precautions will convince you of the extreme care taken to obtain correct results. (See "Competitive Tests of Dynamo Electric Machines," *Journal Franklin Institute*, Nov., 1885.) The dynamo electric machine has grown out of the fact that, if we move a dead wire in the field of another fixed wire, through which a current is passing, the dead wire will have a current generated in it whose electromotive force is proportional to, first, the intensity of the current in the fixed wire; second, to the velocity of motion of the moving wire, and third, to the acting length of the moving wire.

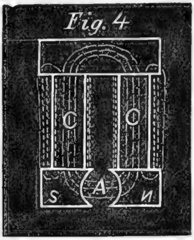
If I take a single wire, Fig. 2, and pass a current through it, its field will resemble a whirlpool of which the wire is the centre.



If I take two wires and place them a short distance apart, Fig. 3, and pass a current in the same direction through both, their fields will combine to form an oval field, and any number of adjacent wires, with currents in the same direction, will do the same thing, forming a field of an intensity proportional to the number of wires and the intensity of the current in each. The field would, however, be of loose texture, so to say, and the lines of force far apart if the lines of force formed themselves around the wires in the air.

Iron, because of its great permeability to the lines of magnetic force, enables us to concentrate this field, and to place it, so to speak, where we desire to use it.

Pure, soft, wrought iron may be said to be 20,000 times more permeable than air.



You will see from Fig. 4 what I mean. The wrought-iron cores C afford the easiest path for the lines of force, and they therefore follow them until they reach the armature space A, between N and S, where they take their airy path across, because the lines of force must always close.

We see that we have thus managed to concentrate the lines of the field of a large number of coils in a small space A. In this space the wires of the armature are revolved so as to generate a current which is either alternating, or approximately continuous.

The details of armatures and winding of them, as well as of the commutators, will be found described at considerable length in the works on Dynamo Electric Machinery, written by Dr. Schellen, or Prof. S. P. Thompson.

I do not think that there is anything written better calculated to give the novice a clear idea of the principles involved in a continuous current machine, than Pacinotti's own description of his machine, which can be found in the translation of Schellen, by Dr. Keith, on page 209.

I have shown you how perfectly the dynamo converts mechanical into electrical power, and I will now have to confess to you how exceedingly imperfect and irregular are the present methods of transformation of heat into mechanical power. Engines and boilers are both built in entire disregard of the actual principles of thermo-dynamics, and there has been so little accurate knowledge of the practical laws which should govern their construction, that makers, in many instances, shelter their wretched designs and workmanship behind the impossibility of predetermining the proportions which will realize the greatest economy of heat.

My own researches have convinced me of the impossibility of using small cylinders with any degree of economy of steam unless they are compounded so as to permit between 8 and 10 expansions.

In the case of non-condensing engines, the boiler pressure should be about 135 to 140 lbs. by the gauge, and in the case of all engines the speed should be as high as is consistent with safety.

Much of this waste is due to initial condensation of the steam on entering the steam cylinder, which was perceived by Watt, and partially remedied by him.

The quantitative law of this condensation, and its influence upon the most economical expansions of steam, I have endeavored to formulate in a paper in the *Journal of the Franklin Institute* for March, 1884, and showed in the same journal, August, 1880, how narrow were the limits of Marriotte's law for the profitable expansion of steam, even neglecting the initial condensation.

Taking matters as they are, the most economical engine used for the purpose of driving dynamos at the late Electrical Exhibition of the Franklin Institute required about 30 lbs. of steam at 90 to 100 lbs. pressure, and the most economical boiler evaporated about 8 lbs. of water per lb. of anthracite coal at the same pressures. That is, an indicated horse-power required $3\frac{3}{4}$ lbs. of average anthracite.

It can be assumed, with close approximation to average correctness, that fifteen per cent of the indicated horse-power is lost in the most direct method of transmission of power from engine to dynamo.

So we can say that one utilizable electrical horse-power per hour may, in good practice, be obtained

$$\frac{3.75}{85} \times \frac{100}{.90} = 4.\frac{9}{100} \text{ lbs. of coal}$$

(such as is sold in the open market as chestnut anthracite), and neglect the loss of electrical energy in the conductors.

The carbon equivalent of the coal used was 91 per cent by weight.

Assuming 14,500 British units as the heat per lb. of carbon, we have

$$4.90 \times .91 \times 14{,}500 = 64{,}655 \text{ B. units of heat.}$$

Assuming the mechanical equivalent of one British unit as 774.1 ft. lbs., we have very nearly 2,558 B. U. for one horse-power per hour. Dividing the last by the first we find that nearly four per cent of the power latent in the coal appears as electrical power in the circuit. Ninety-six per cent of our potential energy is lost; principally in the steam engine.

These facts, taken from the labors of many impartial and skilful workers in scientific research, do not correspond with the alluring statements frequently set before us, but I believe them reliable and practical.

The broad lesson to be drawn from them is that we do not obtain $\frac{1}{25}$ of the power in coal in the form of electricity; and that $\frac{24}{25}$ remain to be obtained by the discoverer of an economical method of direct conversion of heat into electricity.

When the direct method of conversion of heat into electrical energy yields a larger percentage of the power in coal than the indirect method which I have just described, at the same cost, then will the dynamo supplant the steam engine. Until then it must remain what it is—a distributor of power for the steam engine, or other mechanical motor.

The Conversion of Electrical Power into Light.

There are at present in use two methods of converting electrical power into light. The first and apparently the most economical is by means of the voltaic arc between carbon points, the second, by means of the incandescence of a carbon filament in a vacuum.

The first method is open to severe criticism, save on the point of economy and for lighting large spaces.

The briefest look at the intense spot of light formed by the arc between the points of carbon causes a painful and persistent image on the eye. The light has a vicious way of hissing, which become unendurable to sens ive nerves, and it varies the monotony of this noise by sudden jumps and flickers. Its ghastly effects are due to its bluish color and the deep, sharply-defined shadows.

In some cases the arc has a way of rotating around the axis of the carbons, which also causes variations of the intensity of the light in different directions.

Opal glass-globes, which cut off something more than one-half the light, are required to make the light tolerable; and as for the lamp itself, I do not think the greatest skill and taste of designers have yet rendered it ornamental when not lighted.

As a rule, the arc light is most intense when viewed at an angle of 45 degrees from the vertical, and for this reason it is usually used for lighting open spaces from aconsiderable height. I will assume its power as an average of the illumination at 30, 45, and 60 degrees from the vertical.

From the report on Electric Lamps of the Franklin Institute, June, 1885, I take the following data:

Machine.	Angle with Vertical.	Candles.	Candles per El. H. P.	Average Candles per El. H. P.
Arago Disc............	30°	645	783	
	45°	583	708	
	60°	465	565	685
Ball....................	30	182	421	
	45	485	1,123	
	60	520	1,204	916
Brush (1,200 c. p.)......	30	355	762	
	45	613	1,316	
	60	537	1,152	1,076
Brush (2,000 c. p.)......	30	1,200	1,529	
	45	1,373	1,750	
	60	1,082	1,379	1,553
Diehl..................	30	887	1,176	
	45	830	1,101	
	60	725	961	1,079
Richter................	30	603	743	
	45	894	1,101	
	60	960	1,183	1,009
Van Depoele, 20 lights...	30	670	780	
	45	1,377	1,604	
	60	1,060	1,235	1,206
Van Depoele, 60 lights...	30	500	612	
	45	1,162	1,423	
	60	900	1,101	1,045
Western Electric........	30	75	121	
	45	266	431	
	60	355	575	376
	Average........................			994

The average candles per electrical horse-power obtained from measurements upon the Arago disc, Ball, Brush, Diehl, Richter, Van Depoele, and Western electric machines was 994.

The efficiency of these arc-light machines was not obtained, but we are justified in assuming that 70 per cent of the absorbed power will reappear as electrical power in the circuit, neglecting its losses.

That is,

$\frac{3.75}{.85 \times .70} = 6.3$ lbs. of ordinary anthracite coal per electrical horse-power per hour.

$$\frac{994}{6.3} = 158 \text{ candles.}$$

If we divide the candles per El. H. P. by the weight of coal required to produce them, we find in the arc system that we obtain 158 candles per lb. of coal for the naked light, and something less than 75 candles if ground glass or opal globes are used, and the light seen from the most favorable position.

Very different from the arc light is the incandescent. Its light is so soft that we do not realize its brilliancy until we subject it to measurement. It gives out no products of combustion to poison our air; it shows colors truly. A delicate hair of carbon sealed within a vacuum by walls of glass, glitters and glows until at almost limpid incandescence it gives us a steady, clear light, colorless as daylight.

If you will take a book and hold it from one to two yards away from a 16 candle light, you will find it sufficiently diffused to read with comfort.

Now all know that the intensity of illumination varies inversely as the square of the distance. Therefore, roughly estimating a shaded arc light at 500 candles, the same book would have to be held somewhere between $5\frac{1}{2}$ and 11 yards away from it to be read with equal comfort, assuming the light to be steady. We can then say that a 16 candle incandescent light will illuminate a circle of $12\frac{1}{2}$ sq. yards area, and that a shaded arc light giving 500 candles out of 994 will illuminate a circle of 400 sq. yards area, or 32 times as great. That is to say, about thirty-two 16 candle lamps would supply an equal illumination with a vastly better distribution of light for the use of the eyes.

We can, therefore, say that 500 candle power from incandescent lamps will far more than replace 1,000 candle power from the arc light, under the conditions of actual usage.

We can safely say that, for all purposes save that of obtaining light to dispel darkness, the incandescent light is twice as valuable, light for light, as the arc light, and, therefore, should be multiplied by two when compared with it.

The objections most vehemently urged against incandescent lamps have been their short life and lack of economy; this is not true of them in all cases.

The first public test of the life of incandescent lamps was made by the Franklin Institute in the early months of 1885. (*Jour. of the Franklin Inst.*, Sept., 1885.) The record of these tests is given in a pamphlet of some 130 pages, and with a detail which renders it impossible, in our limited time, to do more than gather from its averages such general lessons as we may learn.

From the efficiency test, which was preliminary to the prolonged duration test, we find that 194.1 spherical candles were realized per electrical horse power.

	Spher. candles.
Edison's 97 volt lamps—per El. H.P.	169.2
Stanley's 96 " " " " "	189.1
" 44 " " " " "	216.1
Woodhouse & Rawson's 55 volt lamps—per El. H.P.	209.0
" " " 55 " " " " "	210.8
White's 50 volt lamps—per El. H.P. . . .	182.6
Weston's 110½ " " " " "	209.8
" 70 " " " " "	166.3
Average " " "	194.1

The committee was forced by the different forms of carbon filament used to take the illuminating power of the lamps from all points, and to call the mean the spherical intensity of illumination. This procedure perhaps gives a better idea of the practical value of the incandescent lamp because it is customary to place these lamps in any position that convenience may dictate.

I have already, I trust, convinced you that the incandescent lamp, by reason of its smaller quantity of light and better distribution, is worth at least twice as much as the arc light. I have also told you that one electrical horse-power costs with Weston's incandescent dynamo electric machine about 4.9 lbs. of ordinary anthracite. Therefore 1 lb. of coal will give about 40 candles by the incandescent lamp, and this is equivalent to 80, and probably many more, candles by the arc light, whenever we have to use our eyes for any purpose save guarding our footsteps.

You will recall that under assumptions most favorable to the arc light, I showed you that we probably do not get more than 75 candles per lb. of anthracite from the shaded arc light. Had the committee on arc lights obtained the spherical intensity of illumination of these lamps, their showing could have been made much less favorable than the one given. The present method of arc lighting must ultimately give way before the incandescent light, save for large spaces not requiring a close use of the eyes.

The low potential, and larger current of the incandescent dynamos, render necessary a lower resistance in the conductors, and so the cost of wiring for incandescent lamps is much greater because of the increased weight of copper wire demanded to convey the current without too great a loss in the form of heat. This is the pecuniary obstacle, and about the only one that prevents the entire disappearance of the arc light before the incandescent light. Could an incandescent lamp be made of sufficiently high resistance to enable the use of high potentials the last objection to the system would vanish. Who knows but that in a few days we may hear of its accomplishment?

The Edison 97 volt lamps in this test, outlived all the others; demanded the least weight of conductors, and was 13 per cent less economical of power. It was the only lamp in the test that justified a claim to 1000 hours of life.

Nineteen out of twenty lamps entered by this company survived a continuous test of 1006 hours.

Mr. Weston entered a tamidine carbon lamp, intended to be used with 110½ volts, but imperfection of manufacture subsequently led him to pronounce them worthless.

The more successful lamps were found to undergo a process of gradual degradation which is attributable to two causes, an increase of the resistance of the carbon filament, and a deposit of carbon upon the interior of the glass of the lamp.

The discoloration of the various lamps was carefully compared after their life had ceased, and was remarkably deep in the case of the Woodhouse & Rawson, and the Stanley 44 volt lamps. Indeed, it would seem as if this discoloration was in some wise proportional to the economy of the lamp, as these two were the most economical of the makes of lamps entered.

A lamp may live a long time and yet be of little value for the purpose of giving light, because of this degradation. If you will take a lamp which has been used some time, and lay it upon a white handkerchief, the gray coloring matter on the globe will be brought out quite distinctly.

Thus we see that great length of life with little usefulness may be attained by lamps. Indeed, the Edison lamps, which outlasted all others, had lost 36 per cent of their illuminating power at the end of 1006 hours.

Before turning to my last head, I will remind you that the direct conversion of heat into electrical energy by Clamond's stoves only produced 26 candle power per pound of coke, as against 40 candles per pound of anthracite in the usual way with incandescent lamps.

It will be a surprise to me should not the direct conversion of heat into electrical power prove to have quite as many difficulties, and as narrow limits as the conversion of heat into mechanical power by means of the steam engine.

The Conversion of Electrical Power into Mechanical Power.

The problem which just now is demanding of electricians their most earnest effort, is the transmission of work by means of electricity. This effort will be repaid by the utilization of otherwise inaccessible water-powers; and the problems of locomotion will have their simplest and least objectionable solution when it is an accomplished fact.

Marcel Deprez has recently transmitted 80 horse-power from Creil to Paris with a mechanical efficiency of 53 per cent.

The expense attendant upon an experiment of this magnitude has been very great, but the scientific possibility once proved, we can rely upon the progress of manufacturers to reduce this expense, and to define the limits within which power can be economically delivered.

Seventy-five per cent of the indicated power of the engine is not an overestimate of the power required to move the cable alone for our cable cars on a road of two or three miles length, but it would at once condemn an electric railway, which should be made to yield a practical efficiency of over 50 per cent.

Before discussing the details of the transmission of power, I will, with the aid of our previously-used hypothetical fluid and pipe, and with two pumps to represent the dynamo and motor, endeavor to make clear to you the laws controlling the transmission of power by electricity.

I must again remind you of the fact that I disclaim any knowledge of the real nature of electricity, and that I am reasoning from analogy alone.

Assume two pumps, Fig. 5, A and B, connected by a closed line of pipe so that the fluid must be pumped round a closed circuit. Let the pump A be driven by means of any external power. Let the pump B be reversed and acting as a motor. Let each of these pumps have a vertical stand-pipe projecting from its top, which will show the head E or e resulting from its action. The pump A acts under the law that its head E is proportional to the speed at which it is driven. The motor B acts under a similar law that its counterhead e is proportional to the speed at which it is allowed to run. The weight of fluid, per second, passing through the conduit, is directly proportional to the difference of these heads, and, inversely, to the resistance.

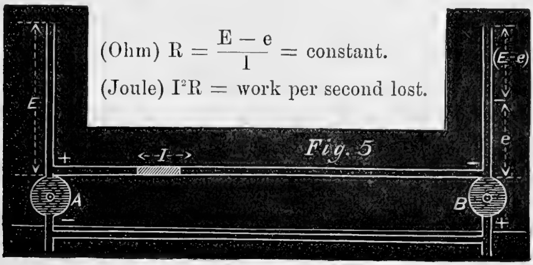
Let I equal the weight of fluid passing along the pipe each cond.

The fluid passing along the pipes between A and B, and through the pumps, will lose, each second, a certain amount of head per unit of weight, because of the resistances.

Let R equal this resistance. Then we can say :

The weight of fluid per second is then directly proportional to the effective head, and inversely proportional to the resistance. This is Ohm's law, which, for electricity, is : *The intensity of the current is directly proportional to the difference of potential and inversely as the resistance.*

The loss of power, per second, in friction in the pipes, is the loss of head multiplied by the weight per second. This is Joule's law for loss in heat for electricity:



$$E\,I = \frac{E\,(E-e)}{R}, \quad R\,I^2 = \frac{(E-e)^2}{R}, \quad e\,I = \frac{e[E-e]}{R}$$

Work per second of pump A = Head × wt. per second.

" " " " " " $= E\,I = \frac{E\,(E-e)}{R}$

" " " lost in pipe A B $= I^2R = \frac{(E-e)^2}{R}$

R = head lost per unit of weight per second.

$I = \frac{E-e}{R}$ Weight per second $= \left\{ \frac{\text{diff. head}}{\text{head lost per unit of wt. per second}} \right\}$ Ohm's law.

Work lost per second $= I\,(E-e) = \frac{(E-e)^2}{R} = I^2R$ (Joule's law).

Work per second of motor B = head × wt. per second.

" " " " " " $= e\,I = \frac{e\,(E-e)}{R}$

Theoretical Efficiency $= \mathcal{E} = \frac{e}{E}$

Work of motor B per second a maximum for e (E—e) maximum that is $e=\frac{E}{2}$

$$\text{Greatest work of motor } B=\frac{E^2}{4R}$$

$$\text{" " Pump } A=\frac{E^2}{2R}$$

The practical efficiency of this combination of pump and motor will be diminished because the head E will require a coefficient greater than unity, and the counterhead *e* a coefficient less than unity.

$$\xi=\frac{e\,(i-x)}{E\,(1+X)}$$

The value of $\frac{1-x}{1+X}$ must be determined by experiment.

It will at once be seen that when the motor is acting at its greatest horse-power the theoretical efficiency is 50 per cent, and its practical efficiency still less, for we must introduce $\frac{(1-x)}{(1+X)}$ as a factor of $\frac{e}{E}$

On the other hand if we increase the counter head *e*, the efficiency of the motor B increases proportionally, but the weight of fluid per second $\frac{E-e}{R}$ becomes less and less, and the work of the motor B per second decreases as $\frac{e\,(E-e)}{R}$ decreases.

But the work of the pump A per second also decreases as $\frac{E\,(E-e)}{R}$ decreases, and the lost work due to resistance to flow through pipe and pumps decreases as $\frac{(E-e)^2}{R}$ decreases.

It seems hardly necessary to call your attention to a misconception on the part of some, and I should not do so now had it not very recently come to my knowledge that a professor, claiming recognition as a high authority in electrical science, is still making the statement that the greatest possible efficiency of an electric motor is 50 per cent.

With a theoretical efficiency of 50 per cent, an electrical motor is doing the largest amount of work in horse-power of which it is capable, but it demands of the generating dynamo twice as much power as it gives out. With a greater theoretical efficiency, it does not turn out so much work per second, but it makes a demand of less than twice its work upon the generating dynamo.

This statement requires to be modified somewhat because of the imperfections of machines, and becomes more accurate in proportion to the perfection of the machines used.

This work lost in resistance of the pipe is plainly a minimum for $E=e$, and a maximum for $e=o$ if R remains constant. Let us separate it into its component parts.

We see from the above equation that $\frac{(E-e)^2}{R}$ = constant when R varies as the square of the difference of the heads, or when the square root of R varies as the difference of heads.

If now we assume the resistance of the pumps as trifling in comparison with that of a long pipe or pipes connecting them, we see that we must double the difference of heads $(E-e)$ in order to have the same loss of work per second with a pipe four times as long.

Increasing the resistance four times gives us only $\frac{1}{4}$ the weight of fluid per second assumed to be passing through the pipe, but doubling the difference of heads also doubles the weight of fluid per second, so that under the altered conditions we obtain $\frac{1}{2}$ the weight of fluid per second, and twice the effective head. Therefore the work per second lost in the pipe is

$$2\,(E-e) \times \frac{1}{2}\,\frac{(E-e)}{R} = \frac{(E-e)^2}{R}$$

as before.

The work done by the pump and motor, each working with twice its former head remains the same as before, and their relative efficiency is the same.

This is what Marcel Deprez meant when he said:

"*The useful mechanical work and the efficiency remain the same whatever be the distance of transmission, provided the electromotive forces, positive and negative, vary proportionally to the square root of the circuit's resistance.*"

I should like to emphatically call your attention to the deadly nature of the very high electro-motive forces demanded by this law, in the case of great distances.

One cannot but admire the boldness of this knight of science. In the face of mistatement, based on erroneous assumptions, and of ridicule and opposition, in many cases becoming personal, he has adhered to his views and won his battle.

His detractors, while now forced to admit his results as correct, have shifted their argument from a scientific basis to a pecuniary one. One would think that so shrewd a financier as Baron Rothschild is not likely to be misled, and can safely afford to discount adverse editorial opinions, in the belief that a successful outcome will be reached before many years.

Let us hastily review the public experiments, which epitomize the results of his labors.

In 1881, at the Paris Electrical Exhibition, he exhibited in the Palace of Industry, one dynamo furnishing power to 27 different pieces of apparatus. No measurements of efficiency were made, as the question of distribution was the only one then to be solved. He, however, then stated that it was possible to transport a useful work of 10 horse-power 31 miles by means of an ordinary telegraph wire, with the expenditure of only 16 horse-power on the generating dynamo, realizing $62\frac{1}{2}$ per cent mechanical efficiency.

At the Munich Electrical Exhibition of 1882 over a line of telegraph wire 36 miles he obtained an electrical efficiency of 39 per cent, and an actual mechanical efficiency of 30 per cent. In his experiments on the lines of the Chemin de fer du Nord, March 4, 1883, he transported 5.6 horse-power $8\frac{1}{2}$ miles over ordinary telegraph wires, with 9.7 horse-power at the generating dynamo realizing an electrical efficiency of $69\frac{1}{2}$ per cent, and a mechanical efficiency of $58\frac{3}{10}$ per cent.

In his experiments, announced October 16, 1885, he obtained from his first, 77 per cent electrical, and $47\frac{7}{10}$ per cent mechanical efficiency. In the second experiment he obtained 78 per cent electrical and $53\frac{4}{10}$ mechanical efficiency by means of dynamometric measurements. The distance between these two points is 56 kilometers, about 35 miles. The speed of the generator varied from 170 to 190 times a minute, and there was no appreciable heating.

Tabulated results of experiments of Marcel Deprez—Convection of work between Creil and Paris:

	First Experiment.		Second Experiment.	
	Generator.	*Motor.*	*Generator.*	*Motor.*
Turns per Minute......	190	248	170	277
Diff. of Potential.....	5469 Volts.	4242	5717 Volts.	4441
Current...............	7.21 Amperes.	7.21	7.20 Amperes.	7.20
Work in Field.........	9.20 H.P.	3.75	10.30	3.80
Work in Armature.. ..	53.59 "	41.44	55.90	43.40
Measured Mech. Work.	62.10 "	35.80	61.	40.
Electrical Eff..........	77 %		78 %	
Mechanical Eff.	$47\frac{7}{10}$ %		$53\frac{4}{10}$ %	

Resistance of line, 100 ohms.
" " generator, 33 ohms.
" " motor, 36 ohms.

Diameter of wire = 5 millimeters of copper wire.

$$\frac{35.80}{62.10 + 9.20 + 3.75} = \frac{35.80}{75.05} = 0.477, \text{ for first experiment.}$$

$$\frac{40}{61 + 10.30 + 3.80} = \frac{40}{75.1} = 0.534, \text{ for second experiment.}$$

The labors of Marcel Deprez have both theoretically and practically opened the way and proved the entire feasibility of transporting great amounts of power for long distances. Much remains and will yet be accomplished in the way of cheapening the first cost of apparatus required, and also of rendering it automatic.

Perhaps the first condition to be placed upon a motor used in manufactures is that its speed shall be regular under all variations of load. Now we know that with a constant field intensity H, and length L, of armature wire the speed V, and the counter electro-motive force *e*, vary together.

$$e = HLV \quad \frac{e}{HL} = V = \text{Constant.}$$

We see, then, that if we demand a constant speed and cannot vary the length of the armature wire, the intensity of the field must vary with the counter electro-motive force.

This can be accomplished by means of double enrollment, commonly called "compound winding," patented by Marcel Deprez, in 1881.

I have already explained to you how the lines of force of the field are led by iron cores surrounded by coils of wire to the spot where the armature in revolving can cut them. If the whole current generated in the armature is led through the coil around the magnet, and then through the external circuit, the winding is technically called series winding. If only a part of the current is taken off at the binding posts of the machine, and led through the coils around the magnet and back to the armature, the winding is technically called shunt winding.

The resistance of the shunt-wound magnet coils is usually much greater than the external circuit, but the number of turns also is greater, and so we attain a field of equal intensity.

Compound winding consists of the joint use of these two methods.

Mr. F. J. Sprague has recently (April 7th, 1885) patented a very clever combination of shunt and series windings for the purpose of obtaining a constant speed of motion for a constant potential circuit, such as is ordinarily used for incandescent lighting.

$$\frac{e}{H} = \text{constant} = \frac{e_1}{H_1}$$

Let Rs = resistance of shunt field coils.
" Ns = number of turns of shunt field coils.
" Rd = resistance of series field coils.
" Nd = number of turns of series field coils.
" E = potential at terminals of motor.
" I = intensity of current through series coils.
" R = resistance of armature.
E—RdI = potential at shunt terminals = Es.

$$\left.\begin{array}{l} \dfrac{E-RdI}{Rs} = \text{amperes in shunt coils.} \\ \dfrac{E-RdI-e}{R} = \text{" " armature.} \end{array}\right\} = \text{amperes in series coils.}$$

from the first equation we have

$$\frac{e}{Ns\dfrac{Es}{Rs} - Nd\left(\dfrac{Es-e}{R} + \dfrac{Es}{Rs}\right)} = \frac{e_1}{Ns\dfrac{Es}{Rs} - Nd\left(\dfrac{Es-e_1}{R} - \dfrac{Es}{Rs}\right)}$$

$$\text{Eliminating } \frac{Ns}{Nd} = \frac{R + Rs}{R}$$

The magnetizing currents in shunt and series windings are sent in opposite directions, and the number of shunt windings is to the number of series windings, as the sum of the resistances of the series windings and the armature is to the resistance of the armature.

This condition produces a magnetic field whose intensity is directly proportional to the counter electro-motive force, provided the magnets have not reached saturation.

Mr. Sprague, by ingenious devices, causes the currents to act together to start the motor with a very strong effort, and, once started, reverses one current and sets the contrary currents in the field coils to balancing each other, so as to produce a constant speed.

For constant potential circuits, this motor will not govern if its theoretical efficiency is less than 50%. On the other hand for constant current circuits such as are used for arc lighting, this motor will not govern if the theoretical efficiency is greater than 50%. We need not discuss it.

To avoid sparking at the brushes, Mr. Sprague has added a third series coil which causes, in the case of dynamos having consequent poles, a counter distortion of the poles of the field magnet proportional to the increase of strength of the armature magnet.

Indeed, it would seem as if he had come very near realizing the ardent desire of all mechanics regarding their machines—"Once in order always in order." For economical reasons, motors running on arc circuits with a constant current, should have other methods of governing than the use of compound reversed coils.

Mr. Weston uses two methods for obtaining a constant speed. The first is by using belts upon reversed cone pulleys, which, with the aid of a centrifugal governor, shift so as to retain a constant speed for the driven machine, whatever be the variations of speed in the motor. The second is to vary the intensity of the field by means of resistance controlled by a governor or other automatic device. In our equation of condition for a constant speed, we observed two suggested methods of procuring this constant speed. The first was to vary the intensity of the field with the counter electro-motive force. The second was to vary the length of the wire in the armature coils.

This latter is manifestly impossible with the ordinary forms of machines, although it is not impossible that part of the field might be cut off, or the armature itself partially removed from a constant field.

Another way is to vary the counter electro-motive force of the motor by shifting the brushes around the commutator, but this is usually productive of sparking, and results in injury to both brushes and commutator.

The number of variations of this method is legion, and I would only weary you by recounting them.

For the purposes of locomotion, special arrangements to produce a uniform speed are not required. From all parts of the civilized world we learn the steady progress of the successful application of dynamic electricity to problems of locomotion.

In the transmission of power by electricity, the ends to be reached can well be stated under these heads:

(A.) Each receiving apparatus should receive its part of the generated power, and, whatever be its action, should not influence other apparatus on the same circuit.

(B.) The efficiency must be independent of the number of apparatuses in action.

(C.) When a regular speed is desired, the regulation should be automatic and instantaneous, and should not require the intervention of an attendant.

Coming, as I do, from almost a year of unremitting experimental labor in a very small portion of the field I have this evening attempted to cover in an hour, I can only compare my lecture to an attempt to compress a bushel of solid matter into a quart measure.

I hope, however, that I have led you to believe with me that there is nothing of the mysterious left in the laws of dynamic electricity, and that with our thorough knowledge of its laws, a thousand heads. a thousand hands will make it transport to us at will heat, light, power, sound, sight, and chemical work.

January 4, 1886.

REGULAR BUSINESS MEETING.

The President, DR. J. S. NEWBERRY, in the Chair.

Thirty-seven persons present.

The following persons were elected Resident Members:

MR. F. J. H. MERRILL,
MR. R. M. CAFFALL,
GEORGE W. WINTERBURN, M.D.,
J. W. BARTLETT, M.D.,
MR. H. T. WOODMAN.

Professor WILLIAM LISPENARD ROBB, of Trinity College, Hartford, Conn., and DR. GIACOMO BONI, of Venice, Italy, were elected Corresponding Members.

MR. P. H. DUDLEY read a paper on

FUNGI INDUCING DECAY IN TIMBER.

(Illustrated with specimens of the fungi of the decayed wood, and with lantern views of photo-micrographs.)

The fungi are leafless, flowerless plants, containing no chlorophyll, and instead of propagating by visible seeds, have only microscopic spores, which are freely disseminated by the air to resting-places. If proper conditions for germination are present, the spore sends out a delicate mycelium, inducing sooner or later a decomposition of the structure of its host, in order partly to build up its own; and it is only later, when fructification takes place, that the presence of a fungus may be suspected.

The species of fungi named by writers as causing the so-called "dry rot" in timber are, namely: *Merulius lachrymans* Fr., *Polyporus hybridus* Fr., *Polyporus destructor*, *Thelephora do-*

mestica, Boletus destructor, Cerulius vastator, Agaricus mellus, and Dœdalia vorax. The names of the first two are generally mentioned and do duty for all occasions. The second is the one found so destructive to the English naval vessels built of oak.

The mycelium of a fungus is not sufficient, at present, for mycologists to identify species, and this is one reason why the list is so small. I have only found *Merulius lachrymans* Fr. a few times in bridges and cars, never on ties. The others of the list I have not found, but in their place many which are sufficiently destructive to satisfy all needs without importing foreign varieties. While at this time I only add a few names of species, there are hundreds yet to be identified which aid in inducing decomposition of wood:

Lentinus lepideus Fr., scaly lentinus.
Agaricus americanus.
Polyporus applanatus Fr.
Polyporus versicolor Fr.
Polyporus lucidus Fr.
Polyporus salicinus Fr.
Polyporus nidulans Fr.
Polyporus sulfureus Fr.
Polyporus gilvus Fr.
Polyporus pergamenus Fr.
Polyporus abietinus Fr.
Polyporus pinicola Fr.
Lenzites vilas Pk.
Hydnum septentrionale Fr.
Fistulina hepatica.
Dœdalea confragrosa Pers., *lenzitoid form.*
Panus stypticus Fr.

I have placed *Lentinus lepideus* Fr. first on the list, for in this immediate territory it is the one so destructive to timber of yellow or Georgia pine (*Pinus palustris* Mill.). I have also found it upon *Pinus mitis.* Being the first to call attention to its destructive influence, its brief technical description will not be out of place, as given in "Cooke's Handbook of British Fungi."

"Pileus fleshy, compact, tough, convex, then depressed, unequal, pallid-ochraceous, broken up into darker spot-like scales; stem stout, rooting, tomentose, or scaly; gills sinuate, decurrent, broad, torn transversely striate, whitish. On stumps of firs, rare (U. S.)." Monstrous forms occur in dark situations with or without a pileus. On the gills or laminæ are borne the spores, 3.5 × 8 micro-millimetres, curved, and one end apiculated, which drop out and are carried by the wind to some resting-place. The mycelium fruiting only under very favorable conditions, the fruit is not easily found. A specimen is here shown. I have seen many thousands of ties destroyed by it without finding the fruit. Its mycelium is very abundant, and pierces the coarser cells of the wood with great rapidity, generating sufficient moisture, having an acid reaction, to carry on its destructive work, provided external currents of air and heat are not sufficient to dry the wood. Examining many pieces of bridge timbers which were horizontal, I found where they had rested on others sufficient moisture had collected to germinate the spores, and the mycelia had followed the longitudinal cells from each way, until they had met in the centre between the supports. The outer portions of the timber remaining dry did not allow the moisture to escape, and the fungus was destroying the inside, while the outside looked sound. I have here a part of a bridge plank. The moisture accumulated where it rested on the joists, the mycelia working each way and upwards, leaving a thin portion of one-eighth to one-quarter of an inch in thickness, giving the appearance that it was all sound. The abundant fructification during a brief, warm rain in September, 1883, was the first indication of the destruction which had taken place. In ten minutes walk from this hall, we could see many thousands of feet of timber destroyed by this fungus, while the cause of decay is hardly suspected.

The upright cells or tracheids composing the annual ring of the *Pinus palustris* Mill. are of two kinds; one of thin, and the other of thick walls. The former fill the inner part of the ring, the latter the outer portion, giving the great strength and hardness to the wood. Interspersed through the ring are a few resin ducts. In decay induced by its special fungus, the mycelium often separates some of the annular layers, and in most cases the thin-walled cells are softened first. On railroad sleepers, larvæ from one-sixteenth to one-eighth of an inch in length, eat and bore through the softened fibres, so that in ties of four to seven years' service we often find little more than a series of nearly separated shells. The mycelium of this fungus, once in the road-bed, is, in summer time, ready to attack new ties of this timber as soon as put in the ground. I have noticed ties, taken up after a short service of six to eight months, which were covered on the bottom by the branching mycelium, and after drying one-eighth to one-fourth of an inch in depth, would crumble to dust. This is the so-called *dry rot.* It takes much longer for the mycelium to destroy the yellow-pine sleepers from the bottom and sides than when it has access to the ends. In the first case, it must nearly destroy the small medullary cells to reach the various rings, while from the end it has a larger area of the rings, which it readily follows. Painting the ends of the timber offers but little protection if the slightest opening occurs, as a spore can enter, grow, and carry on its destruction for a long time before it shows exterior decay.

The structure of each longitudinal cell of this wood consists of three lamellæ, a thin inner one surrounding the lumen, then a thicker one, then a thin outer one which joins that of the adjacent cell. Chemicals which dissolve the latter do not attack the other two, and vice versa; thus they can be separated. In the decay of this wood induced by the fungus described, the outer layer seems to be the last destroyed in many of the cases I have studied.

The decay of the yellow pine is a matter of increasing importance to many of the railroads in this vicinity, as they are depending more upon the use of this timber for ties than formerly, while for bridge timber and plank it is indispensable; and it would be difficult to supply its place in the construction of the frames of cars.

The mycelium of *Lentinus lepideus* Fr. is composed of small branching filaments measuring from one to two micromillimetres in diameter. With the mycelium I generally find an abundance of crystals of one form of oxalate of lime. Sometimes small imbedded cells of other fungi are seen; also other minute forms in adherent masses, the individual cells being quite beyond the definition of present microscopes. These lower species which act as the allies of *Lentinus* are difficult to trace. The destructive power of this fungus is very great, and it is causing enormous losses to users of timber, which are not realized or even suspected.

The remaining species of fungi in my list are those which I have thus far identified as inducing the so-called "*dry rot*" in various woods. *Polyporus versicolor* Fr. is very common, as I find it upon the sap-wood of the white and red oak, and chestnut ties; also upon the sap-wood of chestnut and locust posts, and on the sap-wood and heart-wood of wild cherry, and once on hemlock boards. As a rule, it is more abundant on sap-wood of the oak than on chestnut ties. My observations refer to the entire length of the Boston and Albany R.R., and parts of many other roads in Massachusetts. On the heart-wood of the white oak ties, I have only identified *Polyporus applanatus* Fr., which also attacks the sap-wood of many other kinds. The heart-wood of chestnut ties is not so quickly attacked by fungi as some other woods, since most of them are removed on account of mechanical destruction of the fibres under the rails before decay takes place. I have several samples of the mycelium in chestnut tie (this one from the yard of the Grand Central Station), but have only found a few undeveloped efforts of fructification. *Fistulina hepatica* was found on chestnut wood. The special habitats of the others need not be mentioned. These higher species of fungi are some of those which induce the so-called "dry rot" in timber, so often considered as taking place when the wood is perfectly dry. This is a misconception, as it is impossible for decay to commence without moisture, sufficient heat, and access of air to supply the amount of oxygen needed in the reduction of the tissue to lower compounds. "Dry rot" was named from the effect produced, and to distinguish it from the so-called wet rot. It has been an unfortunate designation, misleading many people, and causing them to believe that timber will rot when dry, and hence proper precautions have not been taken to prevent decay, on the supposition that it would occur in any event. When a fungus has attacked a piece of timber, and subsequent dryness arrested further decay, the tissue affected cracks and crumbles to dust, and people often tell me "there is the evidence of dry rot destroying dry timber"—an effect mistaken for a cause.

The mycelia and fruit of the fungi given in my list all show an acid reaction; and in the decayed yellow pine an acid was associated with a gelatinous mass, insoluble in alcohol, but partially so in hot water. A drop of the latter on evaporating left a gummy residue, and small crystals formed, similar to those of oxalate and phosphate of calcium. By adding other reagents, a variety of different crystals were produced.

From the fruit of *Polyporus pinicola* Fr., a considerable quantity of phosphoric acid, potash, and lime were obtained. The watery extract from this fungus nearly resembles, in composition, the artificial preparations used for the cultivation of moulds, and is quickly transformed by them in a few hours, showing an abundance of yeast cells and rhombohedral crystals. This is a feature of great significance, being an important aid in hastening decomposition, at least. If there is a free aerial growth of the fungi, drawing its supply of oxygen from the air, there is a rapid destruction of tissues, and little is left of the structure. When the air is limited, there is a slower destruction, and more of a fermentative action. In the latter, in the many cases so far studied, I have found an abundance of crystals. The so-called "wet rot" is the result of slow fermentative action, and when produced by the lower order of fungi, *Sphæriacei*, the mycelia found in the cells are dark-colored and jointed. These mycelia are sometimes of long, and again of nearly spherical cells, which pierce the cell-walls of the wood and fill the medullary rays, making them look dark. Some species fruit in the cells near the outer surface. I have a piece of one of the original oak ties put down and completely covered by sand and paving, in the Grand Central Station, in 1871. It was taken out last month. The strength of the wood is destroyed, and it will crumble on further drying. I found several budding cells of ferment similar to the yeast plant in appearance, and a few cells of the genus *Protococcus,* and an abundance of dark hyphæ, which give color to the wood in streaks. In what were checks in the wood when put down, are the remains of perithecia of some of the *Sphæria.* The action here was very slow but sure; the outer lamella of each cell being destroyed more than the others. By wetting and careful manipulation, they can be separated, showing their form more perfectly than those obtained by the ordinary maceration. Some of the *Sphæria* grow under the bark of live trees, sometimes killing them, and are ready, as soon as vital functions of the tree cease, to pierce their host with the abundant hyphæ, and carry on their work of destruction.

I find on unpainted telegraph poles many places where the growing perithecia have burst and broken one to two layers of the wood-cells; and this is repeated as fast as the proper conditions ensue, thus aiding in the mechanical destruction of the tissue. Near the ground line, other fungi send out mycelia which follow down the cells of the wood rapidly, but pierce the wood transversely in a slower manner. As the mycelia get farther away from the air supply, the fermentative action becomes more marked. I mention these points for the reason that, when examined separately, it is hard to understand their connection; and it is the consideration of these two extreme conditions which has led to part of the controversy regarding the relation of fungi to decaying wood. There is less real distinction between the so-called "dry rot" and wet rot than is usually supposed, as both must have moisture, a suitable temperature, and some air to induce decay. Though the final result is the same in all cases, it does not occur in the same way in all kinds of wood.

The subject must be treated specifically, and not in the general manner adopted by writers. Each species of tree has special fungi, as it has insects, which are not found to any extent upon other kinds of wood. Red cedar, cypress, yellow pine, are not affected, as a rule, by the same fungi which quickly destroy the sycamore, maple, hickory, and bass wood.

The structure of all these woods, their stored products, and the intercalated substances in their cellulose walls, differ from one another, as do each of our extensive flora of over four hundred species, and they are distinguishable under the microscope by a difference of cell structure, arrangement, and chemical products as readily as the botanist recognizes them by exterior growth of form, leaves, flowers, or fruit.

The chemical composition of wood is not practically alike, as recently stated, but differs even in the sap-wood and heart-wood of the same species. Some of the woods have compounds in their cells, easily induced to decompose and start the wood tissue, while others have different compounds, requiring inducing agents of greater intensities to begin decay.

A study of the growth and functions of the fungi enables us to understand why, in practical operations, it is so difficult to prevent large timber from decaying internally, while remaining sound upon the exterior. The spores so abundant in the atmosphere find ready lodgment in the checks of the timber before it is thoroughly seasoned. These are inclosed by boarding, painting, or exterior treatment, or even exposed to the sun so as to dry the outside and thus prevent the evaporation of the internal moisture, and the spores germinate and either grow a mycelium or set up the fermentative action, destroying the inside of the timber, leaving a mere shell outside. This was the case with the painted Howe truss bridges, erected for the western railroads; many of them rotting in four to five years. Roads which were too poor to paint the bridges the first year, found they lasted longer. These were very instructive lessons to me, and, in 1873, when designing and erecting a series of long railroad trestles; I made my posts six by eight inches, using two, set three inches apart. This allowed them to season, and gave me about the same factor of safety as one ten by ten, which would not season, but would rot in six to seven years. And my trestles are still in use.

The exterior coatings intended to preserve the Nicholson pavement blocks, was about the most effective means which could have been used to destroy them. Many other failures of treated timber are due to this same cause—namely—inclosure of the spores, their growth, and fermentation.

I have here a piece of wood, used for the sheathing of freight cars, which has already undergone initial decay. Its cells contain the germs to destroy it. A coat of paint on the outside, and a little moisture inside the car, would complete the decay. Cars sheathed horizontally retain moisture in the tongueing and grooving longer than those vertically sheathed, and in consequence they are destroyed sooner by the growth of fungus, seemingly a trifling affair, but really of great financial importance.

Some efforts to preserve certain timber for some places have been successful; but attempts to preserve all kinds and sizes on the same general plan, have resulted in many costly failures, and large corporations have lost faith in such efforts to prolong the service of the wood. Why some succeeded and others failed, hardly excited a query, much less an investigation; and hence good and poor methods were equally condemned.

The proof that untreated wood is stable in some conditions is very abundant. Timber and plank in the roofs of foreign buildings are reported to be in sound condition after a service of eight to ten centuries. Piles which were submerged in water and mud are also reported sound after as long service.

We have much older evidence of the preservation of vegetable and animal tissue than that contained in written records. I have sections of coniferous branches supposed to have formed part of the last dinner of the Mastodon, exhumed in Jamestown, N. Y., some years since, and the wood fibre is probably many thousand years old, as the Mastodons have long since been extinct. Dr. Hubbard exhibited here last winter a piece of the Siberian mammoth skin, which must have remained in the ice for thousands of years. It was dried, and in this condition will last indefinitely. Last week Dr. Hubbard gave me a piece to which I have applied moisture and it is now undergoing decomposition—furnishing a rare morsel for countless bacteria.

The evidence of the destructive influence of fungi is older than that of the preservation of tissue. In the beautiful agatized woods of the Triassic period, recently shown here, I find the mycelia of the fungi, inducing their decay, preserved by the infiltrating medium which agatized the woods.

We daily see posts and telegraph poles, after three to four years' service, decaying near the ground line, but above in better condition.

By comparing the difference of service, it can be seen how little change is required to render unstable what would be stable under other circumstances. In roofs there are dryness, circulation of air, plenty of spores, and sufficient temperature to germinate, but the necessary moisture is absent. In the case of submerged piles, there is excessive wet, with insufficient temperature, and exclusion of air, either to carry spores or permit them to grow. In the case of the posts and telegraph poles, we have the spores, the moisture, and the necessary temperature in summer for germination, and decay ensues. The last stated conditions are those in which the great bulk of railway sleepers are placed, and decay will result unless precautions are taken to prevent it. It is not realized how thorough these precautions must be until thousands of decaying sleepers have been examined. In many cases it seems as though each individual fibre must be protected, not only to prevent the germination of spores, but from the stronger attacks of mycelia, which are in many old roadbeds.

To obtain the best results, the *kind* of wood for the service must be first considered. However, this general statement can be made—the tissues of all wood remain sound or decay, according to surrounding conditions. An inducing cause is necessary to start decomposition, which is the function of some of the fungi.

DISCUSSION.

PROF. TROWBRIDGE remarked upon the great practical importance of the study, and fully agreed with Mr. Dudley that moisture must be present to start decay. Wood in the roofs of buildings had lasted over two thousand years, and was still sound. The bridges put up by Towne, which gave him his great reputation, were covered, the timber kept dry, and some of them were still in use, and sound. In reply to his question, whether there was any process which would preserve the timber, MR. DUDLEY said that could not be answered generally. Small sizes of some kinds of timber had been preserved for some length of time, but there was, as yet, no successful treatment for all kinds of timber for all conditions of service.

PROF. TROWBRIDGE said engineers in England seemed to consider creasoting the best treatment.

DR. JULIEN said that these results explained at least one source of the organic acids which do a geologic work in decomposing the rocks. He also noted the presence of mycelia in vegetable *débris* upon and in the soil, as aiding in the production of these acids.

He also queried whether there may not be two stages in the decay of wood—the one initiated by the direct action of the hyphæ of fungi; the other, the so-called "dry rot," in the presence of a far less degree of moisture, insufficient for the further growth or even life of the mycelia, but sufficient for the continued though slow action of an alkaline bacterial ferment.

He suggested that the production of oxalic and other acids might not depend wholly upon the growth of the mycelia, but partly upon oxidation and direct chemical action (eremacausis), due to admission of air permitted by the mycelium boring through, and so opening the tissue of the wood. Also that the production of ozone by the oxidation of the resins in the wood may cause active chemical action when the ducts are first opened.

MR. DUDLEY, in answer to MR. COLLINGWOOD, said that microscopic examination of different woods showed more in relation to the strength than the durability, though it would determine whether the stored products in the medullary rays were in the form of starch, the most stable form, or in sugar, glucose, etc. The catalpa, by its structure, does not indicate the great durability ascribed to it. Woods which have large bundles of medullary rays filled with compounds are more easily induced to decay, as a rule, than those which have smaller bundles. The microscopical examination would show at once whether incipient decay had commenced. In cutting timber and preparing it for use, it was impossible to prevent the access of numerous spores of various fungi in the air, and when proper conditions were present, they would germinate.

Thoroughly seasoned wood could be painted with advantage, otherwise it was an injury, because it held the moistened spores in the wood, and decay would take place.

MR. W. BARCLAY PARSONS gave illustrations from his experience of the variation in the durability of timbers and bridges under like conditions, and discussed the matter of painting and covering bridges. In one old bridge, the oak posts were sound, but the pine chords were gone.

MR. DUDLEY said it was economical to paint bridges when the timbers were small and well-seasoned; but the joints and ends of the timber must be well protected. Timber should be seasoned under cover, and not in the sun. He thought bridges were better covered than painted.

DR. SCHOENEY discussed the subject of fungi attacking wood, as being analogous to human diseases, and its bearing upon the germ theory. In answer to his question, MR. DUDLEY said he thought the mycelium could penetrate the epidermis and corky layer of living trees if moisture could soften them.

DR. BRITTON briefly described the life history of these higher fungi.

PRESIDENT NEWBERRY commended the paper, and spoke of the importance of the study. He had in his museum specimens of wood from the Egyptain catacombs, which, by being kept dry, had been preserved three thousand years; moisture is necessary for decay; and there is no "dry rot."

MR. DUDLEY said the first Nicholson pavement was of seasoned wood, while later unseasoned wood was used, and the pavements were short-lived. He thought that it was practicable to exhaust air, and fill pores of small timbers with antiseptic fluid, but not of all kinds of large timbers.

January 11, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

A large audience assembled in the west lecture room of the Library Building, Columbia College.

The second lecture of the Popular Lecture Course was delivered by PROF. EDWARD S. MORSE.

Subject: PREHISTORIC MAN IN AMERICA
(Illustrated with blackboard drawings).

January 18, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the Chair.

Thirty-eight persons present.

DR. O. P. HUBBARD exhibited a siliceous sponge from Moriches, L. I. The PRESIDENT said he had received them from other localities on the coast of Long Island and New Jersey. DR. BRITTON said the species was *Suberites compacta* Verrill.

DR. HUBBARD also showed a plate by Petrie which represented borings in stone at Gizeh similar to those made to-day by the diamond drill. The PRESIDENT described the method probably employed.

DR. J. J. FRIEDRICH exhibited some rocks and minerals from New York Island, and read the following

NOTES ON LOCAL MINERALOGY.

It is a well-known fact that tourmaline is sparingly found on the east side of Manhattan Island, except in boulders between Third and Fourth avenues and 99th and 104th streets. Lately, however, I found a locality in an excavation in East 47th street between First and Second avenues, where tourmaline is very abundant in the top rock, consisting of coarse granite. In some portions, tourmaline forms an essential constituent of the rock, which then deserves rather the name of schorl. This rock also contains traces of green tourmaline and green garnet. Green feldspar is also frequently met with.

From the same locality, I have some nicely crystallized specimens of an iron pyrite, probably marcasite, found between the lamellæ of large lumps of mica and adhering to them. It took a very sharp knife to separate the lamellæ, whereby the crystals were often destroyed, as the material is very thin and brittle.

I further have to present some specimens of chalcopyrite in epidote rock found in an excavation in East 96th street, between Third and Lexington avenues. Some of the workmen found pieces of considerable size, as large as a hen's egg. The epidote rock appears at the surface from this locality up to 101st street.

The PRESIDENT exhibited some tubes of earth built up by pupæ of *Cicada* on the floor of a dark, dry cellar.

DR. R. P. STEVENS read a paper

ON THE SAN JUAN MOUNTAINS OF COLORADO.

In the southwestern portion of the State of Colorado lies an area of fifteen thousand square miles of eruptive rocks, extending from Mt. Gunnison on the north, to New Mexico on the south, and from Saguache on the east, to San Miguel on the west, one hundred and twenty miles. Some fifty miles of the west end—that portion which lies in the counties of Hinsdale, Ouray, San Juan, and San Miguel—is the subject of this communication. These mountains are unlike any found in the Eastern States, and unique among those of the west. Looking at them from the mesa country on the south, west, or north, they appear to rise quite abruptly from their base, and are depicted on the sky in sharp needles, minarets, and domes, and seem to stand alone without any connection with any other range. But looking at them from the east, they appear to be connected with ranges that extend as far east as the great bend of the Rio Grande

River, to the south at Alimosa. In their structure, they do not resemble the connected ranges.

We enter this group of mountains by railroad at Durango, coming in over the northern rim of an extensive cretaceous coal basin. We see coal out-cropping high up in the hills.

Going up the Animas river, cliffs and hills of stratified sandstone rocks are seen on either side. They all dip southward, and are of various colors; white, gray, and red are predominant. At Tremble Springs, we find in the cliffs back of the hotel, a black limestone filled with *Athyris subtilita.* Here we also found two species of *Productus.* These fossils are sufficient to identify the age of the rocks as Carboniferous. These rocks extend up the Animas to Rockwood, where they rest on Silurian, and this on red granite. The cañon of the Animas, with its perpendicular walls, is in granite. Metamorphic rocks come in near the first railroad bridge and reach to Needleton. The Needle mountains are quartzite. In Pidgeon Peak and Mt. Æolus, they rise in sharp peaks of quartzite 12,800 feet above sea level.

From Needleton on up the Animas cañon, we are in metamorphic rocks. We emerge into the beautiful alpine valley of Silverton, formerly Baker's Park, through a gap between Sultan Mt. on the west, and Mt. Kendall on the east. On the latter, near the railroad bridge, we can see a large patch of white dolomite, which was caught in the grip of elevating forces, and carried up with it. The main mass of this mountain on the south is metamorphic.

Sultan Mt. is an altered sandstone, with slight dip northward. It is full of dykes and cliffs of porphyry, and capped with trachyte. The porphyry is colored blue or purple, and composed of conglomerate and brecciated rock. Topographically, this is the centre of the San Juan Mts. Here we first see whole mountains injected with molten rock, and charged with veins of silver-bearing ores. The natural structure of the mountains is destroyed, and it is only at rare intervals that we can find any remnant of their original condition. Mola's mine is on the south slope of Sultan. The Williams' group is at the base of the east slope, while the North Star extends from near the summit to the base.

In the rear of Sultan, on a branch of Mineral Creek, is situated Bear Mt. Its bright red strata of sandstone lie nearly horizontal, and it is capped with sharp spires of gray trachyte. This mountain gives us a clue by which to interpret all the other mountains of the group. From Silverton to Ouray, by route of Mineral Creek, is twenty miles. Thanks to Mr. Otto Mears, a graded turnpike road has been built along the valley of Mineral Creek, giving a fresh cut of the rocks the entire distance, and enabling us to study as if by artificial sections. Red Mt. Range extends from Silverton to the bridge over the Uncompahgre River, two and a half miles south from Ouray. At the divide between Mineral Creek and Red Mt. Creek, we encounter the rich mines of the Yankee Girl group. The production of silver from this district has been this year $2,000,100.

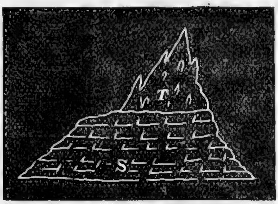


FIG. 1.—BEAR MT.
S, Horizontal sandstone; *T*, Trachyte.

Mears's road shows no other rocks than those of Red Mt. and Mineral Creek, until we approach the village of Ironton. Here we see altered stratified rock. To the north of the creek rises the Sneffles group, high, bold, and projected on the sky.

Owing to its various colors, deep and pale red, purple and yellow, contrasted with the deep brown of the cliffs, Red Mt. forms one of the most picturesque objects of the region, and is scarcely equalled elsewhere. If we proceed up the Animas by the eastern route to Ouray, we find in all the mountains passed only one locality where we can identify the original rock. This is at Denver Hill, where we find altered black slate, probably the same as that which is seen at Bear Creek Falls. In going up the Animas river, we pass by many mountains—King Solomon, with its North Star mine, Galena Mt., with its galena veins, Round Mt., Jones, Grouse, Crown, Cinnamon, Wood Mt., the highest of all, 14,600 feet, Sigel, and, finally, at the head of Animas Creek, Engineer Mt. All these lie between the head waters of the south fork of the Gunnison, the Animas, and the sources of the Rio Grande.

On the left hand going up the Animas we have the south end of Red Mt., Anvil Rock, Boulder Tower, Eureka, and Boneta, at the head of Cement Creek; also Treasure, California, Brown, Hurricane, Mineral Lake, and Denver Hill. Each of these mountains has some peculiar ores belonging to itself. Galena is rich in lead ores, Boneta in gold, Eureka in sulphides of copper and iron, with zinc and tin. At Eureka mural cliffs rise nearly perpendicular a thousand feet and more, while at their base lies a talus of 500 feet at an angle of 45°. The cañon of the Animas reaches to the foot of Engineer Mt.

Here we begin the descent of the Uncompahgre river. It cuts the west foot of Engineer cleanly and boldly, making a natural section of it for more than twelve miles.

Engineer is 12,791 feet above tide. Here porphyry and trachyte rest upon upturned edges of altered stratified rock, and the line of contact can be easily seen, and the thickness of the overflow ascertained. It is some 3,000 feet or more. From the summit down to Ouray is 5,331 feet. We can fall this distance in about eight miles travel; more than half of it is through eruptive rock.

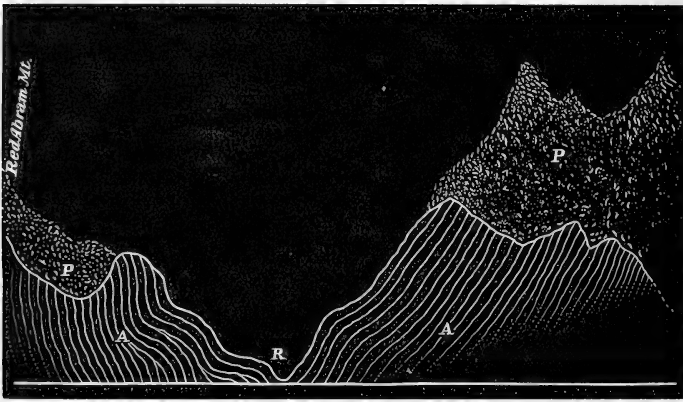


FIG. 2.—SECTION OF MTS. AT SILVER LINK MINE.

A, Altered rock, Quartzite; *P*, Porphyry, conglomeritic, blue, purple and brecciated; *R*, Uncompahgre river.

From a station opposite Silver Link mine, looking east, we see the altered stratified beds standing at a high angle, with northern dip, and rising in cliffs from the lowest depths of the cañon, 2,000 feet, and then 3,000 feet of eruptive rock piled on their summits. The ridges of stratified rock are sharp and well defined, the valleys narrow and not very deep. Here we have the evidence that the San Juan Mts. existed anterior to the outflow and overflow of igneous rock. We can see where stratified beds took an upward bend to form Red Abram Mt.

A section from summit of Engineer Mt. along the old Lake

City trail to mouth of Po'keepsie Gulch gives us four miles of eruptive rock; and two miles of quartzites of various colors bring us to the Uncompahgre Bridge, where we join our section made along Mineral Creek. Just as we dip into Ouray we see a ridge of limestone crossing the highway. On the south side it is highly altered. On the north side it is nearly horizontal. So, also, are all the rocks and cliffs on both sides of the river going north. The famous Mineral Farm mine is probably on this limestone.

Ouray is situated in a cul-de-sac cañon with cliffs of arenaceous rocks rising to the height of 2,000 feet. These form remarkable scenery; they repose nearly horizontal, and are of various colors. They have many entering and projecting angles of perpendicular fissures forming buttresses and bay-window projections, titanic walls, with watch towers and sentinel boxes.

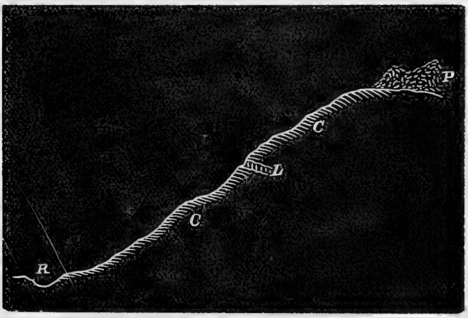


FIG. 3.—SECTION OF HILLS AT CAMP PAQUINE.

R, Uncompahgre river; *C*, Carboniferous sandstone; *L*, Limestone (argentiferous); *P*, Porphyry.

At Ouray begin the northern troubles of the mountains. Here are fissures of great magnitude, faults, downthrows and upthrows. Through fissures issue hot springs—degenerate remainders of former grander springs.

Trachyte has followed us all the way from Silverton, capping the summits of all the mountains we have passed. We go down this valley a few miles and see the mountains fall off into hills, and hills merge into mesas. Two miles below Ouray we find silver in new geological horizons.

One of the layers of rock composing the cliffs is a black, sandy limestone or dolomite. Above it lie horizontal unconformable sandstones. In the vertical fissures of limestone are found silver veins, some of them quite rich. The Nigger-baby, Leadville, and Pony Express are notable. Above the limestone lie 300 feet of sandstone, and far back from the river is seen the usual capping of trachyte. (See Fig. 3.)

Trachyte extends as far as Portland. Silver ores are found in the limestone as far as the trachyte extends, and on both sides of the river.

Lithologically, this limestone resembles a limestone found in the bluffs back of Tremble Springs; it is black in color, somewhat slaty and arenaceous. Fossils in the Animas hills show the rock to belong to the Carboniferous age. Should similar fossils be found in the Uncompahgre it would prove their relationship, and might lead to searching for treasures on the south slope of the mountains.

Ten miles further down the river we find coal of the Cretaceous age—probably the same as that at Durango.

Exactly where on the east the uplift of these mountains begins, with their wonderfully prolific veins of silver, I am not, by personal observations, able to say. But we shall not be far out of the way, if we begin at Lake City and proceed up Henson's Creek.

Immediately we come into blue porphyry, and in a few miles reach Ulay mine, celebrated for its yield, depth, and richness. Continuing up the creek to Capitol City and Rose's Cabin, we see cliffs of porphyry on both sides.

Open mouths of veins are all along with us. At the Cabin we turn to the right hand, and rapidly ascending soon reach the Frank Hough mine, rich in silver and copper, and then the summit of Engineer Mt., or, at the Cabin we turn to the left, and passing by many veins of argentiferous galena, reach another summit, and the main pass of the mountain. Descending this mountain, we come into the widest divide of the San Juan group. We cross it at the San Juan Chief mine and begin on Mineral Mt. the ascent of *The High Trail.*

This trail is worthy of its appellation. Across San Juan County and far into San Miguel, we are never below 12,000 ft. above tide level, and sometimes ascend a thousand feet higher. We pass by the head of the west branch of the Animas and the head of Po'keepsie Gulch.

Here lies a group of rich mines; the most celebrated is the Mountain Queen. The broken slab-like masses of rock look as if they could reveal their original structure, if we had time to study them. We see Lake Como, like an Alpine jewel, lying beneath us. Passing over and around sharp peaks of trachyte, we keep our course westward around the head of

Cement Creek and Eureka Gulch, into Ross' Basin. We follow a sharp ridge dividing waters flowing north from those flowing south to Congress mine, and so on to the rich groups of Red Mt. mines. Here, at the head of Red Mt. Creek, is found the lowest depression, 12,000 ft. above the sea level. We take the Marshall Basin trail and begin again to ascend along a steep mountain side, winding up it as best we can. We flounder through snow drifts in the middle of dog-days. High valleys are filled with snow, calling to mind an ancient glacier which once covered all these summits and moved down the valleys. To the north we see Sneffels group in all their sublimity. To the south lies Mt. Nero. A long saddle of gray trachyte connects the two.

Of all the grand, wild, and sublime scenery of San Juan County, here we find the climax. We are in the midst of peaks with higher and grander peaks farther out on the limits of vision and surrounding us on all sides. Beneath us lies Marshall Basin, half a mile deep, and over two miles long. On the western rim we see the famous Smuggler Vein. We descend the saddle mentioned, by a zigzag trail which clings to the mountains. We see cliff below cliff of porphyry with still many more ahead of us, and pass the mouths of many veins.

At last, as we near the upper levels of the bottom, we turn the sharp shoulder of a cliff and find the Smuggler still a mile ahead; we see it in all its length and beauty. Under the name of Cimaron, it starts in the valley and begins to ascend the western rim of the basin. At the middle it is known as Union and Smuggler. Higher up it goes by the name of Sheridan, and at the summit, of Mendota. Here it dips over into Sneffels Basin, and is known by other names. For more than 5,000 feet it has been proved as a regular, well defined, rich silver lode. It is a cleft in the mountain side, cleanly cut, and well stored with silver ore satisfactory to its owners.

At the foot of this vein, the mountain walls of the basin draw together and form a narrow, deep cañon. Through this, by a steep, narrow, zigzag trail, we descend a branch of the San Miguel river, all the way through porphyry until at the Pandora Mill we find the same stratified arenaceous rocks and limestone that we left behind us at Ouray.

These hills continue down the river a few miles. where the trachyte cap disappears. San Juan Mts. do not extend beyond Telluride; further west is mesa country. To cross them east and west we have travelled nearly forty miles, most of the way on the sky-line, and all the way on eruptive rocks.

Immediately after crossing San Miguel River, at Telluride, we strike into a rolling mesa region. We can follow this around to the head of South Mineral Creek, and return to Silverton.

By two routes we have bisected the San Juan Mts., and found them fifty-five miles wide. We have passed over their summits and wound around their sharp peaks, and find them forty miles long. When we have looked over their tops, the scene was that of a sea of peaks and summits, like a tempest-tossed ocean of chopping waves, without any visible connection with the world below where people live and trade, and commerce flourishes. Every mountain peak has its veins. Every trachytic dome is full of them. Every valley, gulch, and cañon is blessed with them.

One who has studied these mountains well says of them: "There is a vein for every man, woman, and child in them." A bold saying, but perhaps not out of the way when I can count 150 veins, named and owned, within a radius of one and a half miles from the cabin where I live.

The ores that we meet with are silver and silver sulphides. Every known form of silver and its combinations has here been found; also rarer minerals, native gold, molybdenum, zincite, magnesite, and tin. Argentiferous galena is the most abundant; silver with copper is the next so, and silver with antimony comes next. Bromides are rare, so also is chloride.

If I should generalize, I should say that the richest mines are found highest up the mountains in trachytic rocks. I use the terms porphyry and trachyte in their local sense among miners.

No one vein, nor any one mountain, is a clue to another, even in the same neighborhood. Frank Hough mine produces silver with yellow copper, and very little galena. It is the only one on Engineer Mt. Ulay, Capital City, Vermont, and others are purely galena veins. San Juan Chief is a dry ore without galena; its richest streaks are ruby and gray copper. Bill Young is ruby silver with gold. Old Lout is bismuth and gray copper. Sunnyside, with its extension, and Sampson have more native gold than any others. National Belle and Yankee Girl are galena with copper. Smuggler vein has native gold with its dry ores, while at Ophir they work veins for gold alone.

Veins of these mountains are mainly siliceous—silex mixed with soft porphyry, lime, or feldspar. The prevailing course of the veins is N. E. and S. W., but they also run in every conceivable direction. Sometimes they lie in echelon, sometimes they divide, run parallel for a short distance, then the branch re-enters and joins the main vein. At Red Mt., ores are found in chimneys, as if formed or deposited in hot geyser springs. In the veins ores are found in different horizons, which carry different minerals. A vein may be rich at the surface and lean below, or lean at the surface and rich in depths below. They are often of great width, thirty, forty, fifty, and even more feet, and also of great extent. It is said that the fissure of the Smuggler vein can be traced for two miles.

Proving that the trachyte was erupted at different ages, we find veins formed and filled in one age by one peculiar kind of filling, and covered over in their course by another kind of trachyte without any veins whatever.

San Juan veins have produced in the last year *one-fourth* of all the silver of Colorado.

The geological order of events in the construction of these mountains seems easy to read. I speak with diffidence, having not seen actual proof, but I think that the Needles and other elevations at the head of the Rio Grande are much the oldest mountains. At the close of the cretaceous age they were surrounded by a vast plain—part of the great mesa country of S. W. Colorado.

Forces operating from the earth's interior broke through sedimentary strata and forced up masses of metamorphic rock. Inferior silurian, carboniferous, and cretaceous rocks all felt the elevating influence, and were tilted up—turned on edge—or lifted solid and unbroken. They presented rugged heights and deep, narrow gorges. Then followed an age of eruption of thick, tough, pasty material which filled the valleys, covered the rugged heights, and every remnant of mesa country that was caught in its grip. This molten matter was forced through every cranny and crevice of rocks. Sometimes it lifted up immense masses of horizontal strata by what is now called *laccolite* elevation. It seems to have had the power of changing all other rocks it came in contact with into something of its own characteristics; for by heat, steam, and pressure, and the interplay of chemical reactions, the original features of the stratified rocks have been completely destroyed.

It is only at distant intervals that we find any rocks which give a clue to their original condition. In Denver Hill we find an altered slate which we can identify with the black slates at Bear Creek Falls. At the foot of Engineer Mt., in the upper cañon, we find red sandstone slabs not yet fully changed.

This first period of outflow might be called by way of distinction, the *porphyry period.*

Then followed another out-push of melted rock. It came up through small craters, chimneys, and vent-holes. There were many thousands of such vents; each peak had its own set and series of them. The hot material was viscid and tough. While it would not flow, it could be pushed along by a *vis a tergo,* and could be piled up. It could form domes and cones on the top of every mountain, but it was not sufficiently fluid or semi-fluid to flow down the mountain side and fill up the valleys.

This period I should call the *trachytic.*

On cooling, these outflows became fractured and fissured. These fissures became the heated drains of mineral matter, and were charged with precious metals, in siliceous gangues, in the tertiary age.

The evidence of this age I have not seen, but take it as proven by Worthen's surveys. Certain it is, they are now the natural vaults of King Pluto's wealth.

DISCUSSION.

PRESIDENT NEWBERRY said that he had spent seven months in this region in the year 1859, while connected with the San Juan Exploring Expedition, and had described some of its geologic features in his report to Capt. J. N. Macomb, U. S. Engineers.

DR. STEVENS has not exaggerated the picturesqueness of the region nor its mineral wealth. There is no part of the continent where the alpine scenery is bolder and more varied. The Rocky Mt. belt, here two hundred and fifty miles wide, consists of a series of ranges which terminate southerly in echelon—the San Miguel range first, and in succession the Sierra la Plata, Sierra de los Pinos, San Juan, and others. These end abruptly, giving place on the south to a broad plain traversed by the San Juan River and its branches.

The mountains are well watered, snow falling heavily in winter, and showers occuring almost every day in summer, while the plain near by is extremely dry. The latter, however, was once inhabited by a dense population, the Mexican semi-civilized people, who cultivated the soil and built stone houses, frequently of great size, and in such numbers that their ruins are always in sight of the traveller.

The PRESIDENT exhibited specimens of ore from the Madonna mine, Monarch, Colorado, in which the galena had changed to sulphate of lead by oxidation; and by the action of water the latter was given a partially concretionary structure.

January 25, 1886.

STATED MEETING.

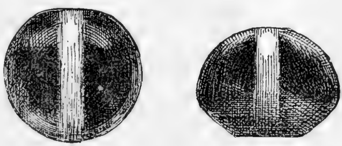
The President, DR. J. S. NEWBERRY, in the chair.

Thirty-two persons present.

MR. GEORGE F. KUNZ remarked upon some

RARE GEMS AND INTERESTING MINERALS.

A few remarkable gems have been recently purchased by private buyers in the United States. One of these is a chrysoberyl cat's-eye, weighing 80$\frac{3}{4}$ carats. Its dimensions are 23 mm. long, 23 mm. wide, and 17 mm. thick. The color, which is very even, is a superb brownish yellow, and the line is as even and distinct as is possible is a gem of such size. The cat's-eye hith-



Chrysoberyl Cat's-eye.

erto awarded the palm is part of the "Hope Collection" in the South Kensington Museum. This famous gem measures 35.5 by 35 mm. in its true dimensions. (The Hope catalogue gives the length as two inches, but this is only the case when measured over the dome). It formed part of the crown jewels taken from the King of Kandy, in 1815. The crystalline markings are so arranged that the lower half shows an altar surmounted by a torch. The line is not straight, but inclined about 15 degrees. The color is dark and the line is not so strongly marked as it should be in a fine gem.

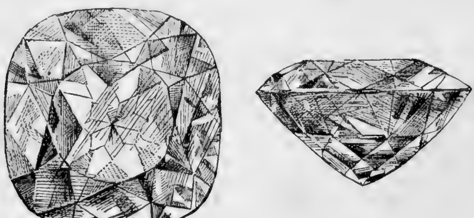
Two of the largest known Ceylonese Alexandrites are to be noted. One of these weighs 28$\frac{23}{32}$ carats, and its dimensions are 32 mm. by 16 mm. by 9 mm. In daylight its fine rich green color is tinged with red, but by gaslight it is a rich columbine red, and scarcely to be distinguished from a Siamese purplish-red spinel. The other stone is the largest on record. It weighs 63$\frac{3}{8}$

FACE. SIDE VIEW.

Alexandrite. Ceylon.
63 3/4 Carats.(Nat Size)

carats, and measures 33 mm. by 32 mm. by 15 mm. It has a yellow, grass-green color by daylight, but changes to a raspberry-red by artificial light.

The finest cut beryl (Aquamarine), ever found in the United States is from Stoneham, Maine. It measures 35 mm. by 35



FACE. SIDE VIEW.

Aquamarine. Stoneham, Me.
133 3/4 Carats (Nat Size)

mm. by 20 mm. It is brilliant-cut and weighs 133$\frac{3}{4}$ carats. The color is bluish-green, and, with the exception of a few hair-like internal striations, is perfect.

A cabochon ruby, from Franklin, Macon Co., N. C., shows somewhat the asteria effect. It is of good normal color and quite free from flaws. Its dimensions are 5.5 mm. by 4 mm., and its weight 1$\frac{1}{16}$ carats.

An interesting banded muscovite from Bear Creek, El Paso Co., Colorado, is composed of twenty alternate layers of brown and white muscovite. The crystal measures 42 mm. in its greatest diameter.

A specimen of quartz, from Arizona, is covered with an alteration of chalcedony and quartz after bent crystals of calcite. The crystals replaced were 12 mm. long by 4 mm. thick ; and the alteration is a replacement pseudomorph.

DR. J. S. NEWBERRY read a paper upon

THE CRETACEOUS FLORA OF NORTH AMERICA.

(Illustrated by drawings and lantern views.)

(Abstract.)

The first information in regard to the vegetation which covered this continent in the Cretaceous age was furnished by a collection of fossil plants sent from Vancouver's Island by Mr. George Gibbs, in 1858. These consisted of leaves of angiosperms and palms described by the speaker in the Proceedings Boston Nat. His. Soc., 1863. With them were casts of *Inoceramus* and *Baculites*, which were indicative of Cretaceous date.

Subsequently Mr. Meek, Dr. Hayden, and the speaker obtained from the "Dakota" sandstones of Nebraska, Kansas, and New Mexico, a considerable number of angiospermous leaves. Tracings of some of these were sent to Prof. Oswald Heer, at Zurich. He pronounced them of Tertiary age, as he had previously done a series of fossil plants obtained from Vancouver's Island by Dr. Evans, and described by M. Lesquereux. As heavy beds of limestone, containing Cretaceous mollusks, were found by Dr. Hayden and the speaker overlying the Dakota sandstones, it was asserted by us that they must be Cretaceous.

A lengthy and animated discussion followed in which Prof. Heer, M. Lesquereux, and M. Marcou contended for a Tertiary, Mr. Meek and the speaker for a Cretaceous date. Finally, Prof. Capellini, of Bologna, and M. Marcou went to Nebraska in 1863, and examined some of the outcrops from which the leaves had been taken. Upon their return, they conceded the Cretaceous age of the deposit, and the fossil plants collected by them were described by Prof. Heer in the *Mémoires de la Société Helvétique des Sciences Naturelles.*

Since that time more than one hundred species of arborescent plants have been obtained from the Dakota group, and have been described by M. Lesquereux or the speaker. These include oaks, maples, magnolias, sassafrases, and various other genera of an aspect so modern that it is not surprising they were considered as Tertiary plants. However, it is now established beyond doubt that, in the middle of the Cretaceous age, a flora hardly less varied than that of to-day, or inferior in botanical rank, covered all the central portions of this continent.

Previous to the time mentioned, plants had been collected from different parts of the Cretaceous system in Europe. From the uppermost beds, a number of angiosperm leaves had been taken *Credneria*, etc.), and from the lower portion of the system, the remains of a truly Mesozoic flora—cycads, conifers and ferns. This had led to the conclusion that during the greater part of the Cretaceous age, the vegetation of the world was similar to that of the Triassic and Jurassic ages. But our recent discoveries in America have thrown great light on this subject, and have somewhat modified the previously-entertained opinion.

Within the last ten years, collections of fossil plants have been made from the Cretaceous rocks in a large number of localities in Canada and in the United States, and some of the most interesting of all the material thus furnished has come from our own immediate vicinity, from the Cretaceous clays of New Jersey and Virginia.

Combining the results of the studies of Sir William Dawson of Canadian Cretaceous plants, with those obtained by M. Lesquereux, Prof. Fontaine, and the speaker in the United States, the development of plant life on the continent can be traced with a good degree of accuracy.

At the same time that the Cretaceous flora was studied in Canada and the United States, extensive explorations and collections were made in Greenland. Among other material obtained there were many fossil plants which were sent to Prof. Heer, and described in his great work, the "Flora Fossilis Arctica," of which he had published seven quarto volumes before his death.

The table given below shows at a glance the relative positions of the plant-bearing members of the Cretaceous system in Europe, Greenland, and North America.

CANADA.	PACIFIC COAST.	INTERIOR.	ATLANTIC COAST.	GREENLAND.	EUROPE.
	Carbonado, W. T.	Upper Laramie.	Eocene.	Eocene ('Miocene')	Eocene.
St. Mary's.	Vancouvers' Island.	Lower Laramie.			Faxoe Beds. Mæstricht.
	Chico, Cal.	Colorado (Marine.)	N. J. Marls (Marine.)	Patoot.	Chalk.
Peace River.		[Colorado (Marine.)]	[N. J. Marls (Marine.)]		[Chalk.]
Mill Creek.	Shasta, Cal.	Dakota.	Raritan.	Atane.	Up. Greensand.
Queen Charlotte.	Shasta, Cal.		Potomac.	Kome.	Neocomian.
Kootanie.					Wealden.

The lower Cretaceous rocks have everywhere yielded fossil plants having essentially the same character, viz., a great preponderance of cycads, conifers, and ferns; with the addition in the upper portion of the Lower Cretaceous strata of a few angiosperms, the leaves of which resemble those of poplars.

In the Wealden and Neocomian of Europe no angiosperms are found. In the Greenland Kome beds are ferns, conifers, and cycads, with two angiosperms, called *Populus* by Heer. In the Kootanie and Queen Charlotte beds of Canada, also gymnosperms, but no broad-leaved plants occur.

In the Potomac clays of Virginia, Professor Fontaine has found apparently the beginnings of the angiospermous flora, a large number of species of cycads, conifers, and ferns, with a few angiosperms.

In the Mill Creek beds of Dawson, in the Dakota group of Nebraska, and in the Atane beds of Greenland, the remains of an abundant angiospermous flora have been discovered. And now we have to add to what was before known of this flora, the important and interesting contribution made by the Raritan or Amboy clays of New Jersey.

These clays have been worked for making fire-brick, pottery, etc., for many years; and have been opened at many points on both sides of the Raritan river. In most of the pits large quantities of lignite have been found, and not unfrequently distinctly marked impressions of leaves. These are for the most part coated with a relatively thick sheet of lignite—the carbonaceous matter of the leaf—which cracks in drying to a powder, and can be blown away. Hence the specimens have been so perishable that they have not been satisfactory objects of study. Within the last two years, however, layers have been found at Woodbridge and South Amboy, in which the leaf-impressions are simply stained coffee-brown, and are permanent. These have been collected and drawn with care, for the Geological Survey of New Jersey, with a view to publication. About fifty quarto plates have already been made up of these drawings. (Some of these were exhibited to the audience.)

The botanical character of this flora is of special interest. The specimens already gathered represent about a dozen species of conifers, as many ferns, two or three cycads, fifty to sixty angiosperms, with many fruits, and some flowers. The conifers include species of *Pinus, Brachyphyllum, Moriconia, Sequoia*, and what have been considered by Prof. Heer as species of *Juniperus, Thuja*, and *Dammara*, though these determinations are somewhat doubtful. About half the conifers are apparently identical with those found in the Cretaceous beds of Greenland, and the most beautiful and interesting one, *Moriconia*, occurs both at Aachen and in Greenland.

The ferns are very similar to those obtained by Heer from Greenland, and some of the species are identical. They have been referred to the genera *Gleichenia, Dicksonia, Aspidium*, etc.

The cycads are closely allied to, if not identical with, species of *Podozamites* obtained by Heer from the Atane beds of Greenland.

The angiosperms include species of *Liriodendron, Magnolia, Sassafras, Aralia, Celastrus, Celastrophyllum, Salix*, and what have been considered by Heer as *Hedera, Ficus, Diospyros, Juglans*, etc. With these are new and splendid species of *Bau-*

hinia and *Hymænea*—leguminous genera, not before identified in the Cretaceous flora of N. America.

The most interesting and unexpected discovery among the angiosperms is that of numerous specimens of a helianthoid composite flower, three to four inches in diameter, in which the ray-florets (?) were scarious and persistent like those of *Heliochrysum*.

Taken altogether, this flora is of surprisingly high botanical rank, quite as much so as that obtained from any Tertiary strata, and perhaps as any local flora of an equal number of arborescent species in the vegetation of the present time.

February 1, 1886.

REGULAR BUSINESS MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Sixty-five persons present.

The following persons were elected Resident Members:

MR. LEVI HOLBROOK,
WILLIAM G. ANDERSON, M.D.

WILLIAM J. HOFFMAN, M.D., Curator of the Anthropological Society of Washington, D. C., was elected Corresponding Member.

MR. P. H. DUDLEY read a paper on

THE INCEPTION AND PROGRESS OF RAILWAYS.

(Illustrated with lantern views.)

The inception of the vast railroad systems antedates the introduction of steam, though the latter gave the impetus to their present development.

It was the imperative demand for better facilities for transporting coals and ores from the mines, and stones from the quarries, that led to the introduction of wooden rails to furnish better ways for the passage of wagons, carts, and finally miniature cars. Short cast-iron rails replaced those of wood, thus preparing the way to receive and develop the greatest type of human progress—the locomotive and its accompaniments.

Newcomen's seemingly crude steam engine of 1710 was a grand conception, a great advance upon Savery's, which raised water but did not have moving parts. Newcomen found great difficulty in having his engine tried at the tin mines to pump water. It was not automatic. A boy was employed to turn the faucet for the introduction of steam into the cylinder to raise the piston, which lowered the pump rods on the other end of the walking-beam; the boy then closed this faucet, and turned another for the injection of water to condense the steam, thus forming a vacuum beneath the piston when the air pressure depressed the piston, raising the pump rods and the water. At first the condensing water surrounded the cylinder, and the engine was very slow in action; a leak occurring, the strokes of the engine were much increased, and caused alarm at the rapidity. This led to the water injection pipe. Humphrey Potter, a boy employed to turn the faucets, soon grew tired of his work, and invented and applied some levers and strings to open and close the faucets, thus rendering the engine automatic, and increasing its speed and safety.

Beighton improved the inventions of Potter, making them a part of the mechanism.

In 1763, James Watt, a philosophical-instrument maker, entered the employ of the University of Glasgow. Their model of Newcomen's engine had been sent to London for repairs, and he induced the faculty to have it returned so that he could study and repair it. He was well versed for his time in the principles of latent heat, having studied under Dr. Black, and was able to appreciate the enormous loss of heat caused at each stroke by heating and then cooling the cylinder. He designed the separate condenser and air pump, thus avoiding the cooling of the cylinder, and introducing greater economy in the amount of fuel consumed.

His specifications in his patent of 1769 for the construction of engines are still models for study in principles. In mechanical execution he encountered difficulties which we cannot appreciate, with our present plants for constructing work of almost any size.

Newcomen's engine is now represented by the Cornish pumping engines.

Watt converted the reciprocal motion into rotary motion, making a motor for general purposes. This is represented today by the marine condensing engine.

Ideas respecting locomotion were developing on every hand; and while many are willing to ascribe the invention of the locomotive to one man, the probabilities are that it was due to many minds, as we know its construction has been. Watt patented, in 1769, a steam carriage, but did not construct one.

Cugnot's locomotive of 1769 would run for a few minutes, until the supply of steam was exhausted. One running in the streets of Paris at about three miles per hour turned over, and was considered dangerous by the authorities and locked up in the arsenal.

In 1784, Murdock, an associate with Watt, made a working model of a locomotive, but no further steps were taken.

Oliver Evans, of Philadelphia, was at this time busy with his experiments upon high pressure engines, and in 1787 patented his steam carriage. In 1794–95 he sent Mr. Joseph Sampson to England with his drawings, where they were shown to many engineers, and it was said that they were copied without giving him credit. In 1801, he constructed his *Oructor Amphibolus*, which mounted on wheels, was propelled by its steam power through the streets of Philadelphia in the presence of 20,000 people, one and one-half miles to the Schuylkill. There it was launched, and then, by a wheel in the stern, propelled around to the Delaware front of the city, a distance of sixteen miles. He was an advocate of steam locomotion, and is accredited with saying "that the time would come when a party could start from Washington, breakfast in Baltimore, dine in Philadelphia, and sup in New York." The realization exceeds the prophecy, yet for such remarks he was considered insane.

Trevithick and Vivian patented a steam carriage in 1802 which was a high pressure engine. It was run in the streets of London, but they were so rough and uneven it was abandoned as a failure. In 1804 they constructed one to run upon the tram roads, and it was tried upon the Merthyr Tydvil Railway, in South Wales, drawing ten tons at a speed of five miles per hour. This was also abandoned ; the great difficulty being insufficient adhesion. To remedy this, Trevithick recommended and caused to be placed upon the periphery of his driving wheels, projecting bolts and grooves, which proved successful for this purpose, but produced a series of blows which broke the cast-iron rails.

In 1811, Mr. Blenkinshop, of Leeds, took out a patent for a rack rail and the necessary mechanism to work in it. I call attention to this; as an improved form, Abt's system, has recently been brought forward to work mountain lines of heavy gradients. To secure sufficient traction, Mr. Chapman, in 1812, stretched a chain in the road bed which also passed around a groove in a drum under the engine.

In 1813, Mr. Brunton brought out his mechanical traveller, the cylinders connecting directly with the legs, which moved the locomotive by a series of impulses. A velocity of two and a half miles per hour was obtained, and a tractive power of four horses.

In the same year, Mr. Blackett, who had long experimented with Trevithick's locomotives, commenced a series of tests with Mr. Hedley to ascertain the amount of adhesion that could be obtained per ton weight of locomotive, and the amount of traction required to draw the trains. They discarded the empiricism of the day, and found the locomotive would have sufficient adhesion to draw the trains without the use of rack rails or ropes. They brought out the famous "Puffing Billy," which is claimed to be the oldest locomotive that did actual service.

It began to draw coal in 1813 and continued in use until 1862, when it was purchased to be preserved in the South Kensington Museum, London. Mr. W. W. Evans, who had visited the museum several times to see it, says "the wooden frame was only brought to size where attachments were to be made." It had two cylinders and grasshopper beams. The boiler was *lagged;* the ends put *on* instead of in; the flanges projecting upwards. The cylinders have the appearance of being double, the outside one being of boiler iron. It had a crank shaft with which connections were made from the beams, giving it motion, thence by gear wheels to the driving axles. The fire door was at the same end as the smoke-stack, which was next to the tender; the axles were square. The wheels under the engine are doubtless of more recent construction, as they are of present forms. The rails beneath the engine are similar to those first used.

The question of transportation and railways was being agitated in this country, and in 1812, Col. John Stevens published his pamphlet on railways, his general ideas being quite similar, it is said, to those of to-day. He stated, "a velocity of 50 miles per hour could be obtained, but a speed of 20 to 30 miles would be more convenient."

In 1814, Mr. George Stephenson constructed his first locomotive, which was geared. It would draw thirty tons at a speed of 4 miles per hour. It had two cylinders, each 8x24 inches; a boiler 8 ft. long and 34 inches in diameter, having one internal flue of 20 inches. The speed of the locomotive was limited by its low capacity for generating steam. The cog-wheels gave a great deal of trouble, and in the next year, Stephenson & Dodd took out a patent for direct connections of the cylinders and wheels, and also for coupling the latter with connecting rods. The engine was carried upon air or steam cushions, which was a great improvement. Springs were afterward substituted for the cushions.

Though the road bed and rails were being improved, it was not deemed practicable to operate the railways by steam power.

The construction of the Hetton Coal Railway, of eight miles, was Stephenson's first important work. The level parts were operated by locomotives, and the inclined planes by stationary engines. While this railway was under construction, other projects were being agitated, and, in 1820, the Stockton and Darlington Railway was chartered, and Mr. George Stephenson appointed engineer. The line was intended for horse power, but he had the charter amended so that it would permit the "passage upon it of wagons and other carriages with men and horses, or otherwise," which proved to mean a locomotive. The great event was the opening of this railway on September 27, 1825, Stephenson on the "otherwise." To this were attached six goods wagons loaded with flour; then the first passenger car, the "Experiment," occupied by the officials of the road; and then twenty-one coal wagons crowded with people. An outrider on horseback with a flag started ahead of the train to pilot, and warn people to keep off the track. The train started with great *éclat,* the banks were lined with people waving handkerchiefs, and many on horseback following the train. No wonder the sturdy engineer, who had overcome opposition at every hand, felt the enthusiasm of the moment, and calling to the outrider "to get out of the way" applied more steam, and soon distanced the horsemen, and left them in a dazed condition. *This was the great step in the progress of steam locomotion.*

The locomotive used on this occasion was called the Locomotion, and is still preserved. In 1883, it was sent to this country, and exhibited at the National Exposition of Railway Appliances, held in Chicago, Ill., and then returned to England.

The Liverpool and Manchester railway, with Mr. George Stephenson as Chief Engineer, was pushing forward, and on April 15, 1829, offered a premium of £500 for the best locomotive, not to exceed six tons in weight, and able to draw three times its own weight, and burn its own smoke. The "Rocket," the "Novelty," the "Sans Pareil," and the "Perseverance" were entered.

The Rocket was built by Messrs. R. Stephenson & Co., which was really Mr. George Stephenson and his son Robert. The Novelty was built by Messrs. Brathwaite & Ericsson, the latter of Monitor fame and now residing in this city, in the 83d year of his age, and still busy with important inventions. The leaking of pipes led Mr. Ericsson to withdraw the Novelty from competition for the prize. Mr. Timothy Hockworth entered the Sans Pareil and Mr. Burstall the Perseverance.

The Rocket won the prize. Alterations were made in it after the trial, and it is now in the South Kensington Museum.

The Rocket combined, for the first time in one locomotive, the essentials of success, viz., the multitubular boiler and the blast of the exhaust steam.

During this time, in the United States, many charters had been obtained for short lines of railways, the first idea being to work them by horse power. Canals had been projected, and some constructed, but they were limited to favorable localities, and could only be operated about seven months in the year. American engineers were in England, studying the railways. Pennsylvania had many short coal roads. The Mohawk and Hudson railroad was chartered in 1826, the Baltimore and Ohio in 1827. This road was constructed to Ellicott's Mills, and the cars were drawn by horses. The subject of locomotives was being agitated, but it was supposed to be impossible for them to pass around the curves of this road, and the directors were discouraged, and "thought their line was ruined." There were no locomotives in this country to test the question, so Peter Cooper rose to the occasion, and in 1829, with gun barrels for boiler flues, made the first American locomotive, and demonstrated to the directors and non-believers the important fact that curves were not impassable obstacles. The pictures extant show it to be a mere toy, comparatively speaking. It burned anthracite coal, the fire being maintained by a fan driven by a belt from the axle.

There was but one cylinder, 3½x14½ inches, which connected by gearing with the driving-wheel axle.

A picture represents the great race on August 28, 1830, between Peter Cooper's "Tom Thumb," and the "gray horse" of Stockton and Stokes' stage cars. The horse is shown in the rear, which was the fact for some distance, though they started neck and neck. The locomotive had passed the horse, and the driver was about giving up the race, when the belt slipped from the fan, the steam ran down, and before it could be replaced the horse passed, and was not overtaken. But the great fact was demonstrated that a locomotive could pass the curves; and the Baltimore and Ohio Railroad Company, in 1830, offered a premium of $500 for the best locomotive which should be able to draw fifteen tons, fifteen miles per hour. The successful one, called the Grasshopper, was built by Phineas Davis, who was killed in the trial trip. Locomotives like this were built for three or four years—some being still in use for switching in yards. They will pass as short a curve as a street car. Then followed the types known as the "Crab," the "Mud-digger," and the "Camel backs."

In 1827 the Delaware & Hudson Canal Co. commenced a railroad from their mines to the end of their canal at Honesdale, Penn., and finished it in 1828. Alive to the importance of steam locomotion, they sent their Assistant Civil Engineer, Mr. Horatio Allen, a graduate of Columbia College, to study the subject in England, and he ordered from there the locomotive called the "Stourbridge Lion," which arrived at Honesdale

July, 1829, and made a trial trip the following 8th of August. It was found too heavy for the rails, and did not go into general service.

At the time when these experiments were taking place, Mr. Horatio Allen was constructing the South Carolina Railroad of 136 miles, exclusively for steam power. The opening was on July 15, 1831, by the locomotive "Best Friend," made at the West Point Works, in New York City. The locomotive "West Point," constructed at the same place, made a trip March 5, 1831.

The firm stand of Mr. Horatio Allen in favor of steam power versus horses, had much to do with developing the early locomotives. He is still living in this city, one of the few men whose life and labors cover the entire space of the history of the railway system. No one can question his foresight regarding the locomotive.

A well-known picture represents the appearance of the first locomotive and train run in the State of New York. A Mr. Brown, who was one of the passengers, cut out with scissors a silhouette of the train. There were three more cars than shown in the picture. The locomotive was the "De Witt Clinton," and the engineer David Mathews. It has been erroneously stated that the locomotive was the "John Bull," and the engineer John Hampson. This train was run from the top of the inclined plane above Albany to the one near Schenectady. I call particular attention to the picture of the locomotive, as through the courtesy of Mr. William Buchanan, I am able to show a view from the original drawing of the "De Witt Clinton," which will correct some errors in its history. The Franklin Institute has a drawing representing the De Witt Clinton without a dome. This was the "Experiment," and the two have been confounded. The "Matt. Baldwin" locomotive shows the four-wheeled truck, which was the invention of the late Mr. John B. Jervis, the eminent American civil engineer, and is the distinguishing feature of American passenger locomotives.

The preceding will be sufficient to illustrate the early struggles of the locomotive. Crude as they now may seem, they were wonderful in their day, reflecting great mechanical skill and wisdom in that direction. One improvement was but the precursor for others to follow.

Simple as the results now seem to us, their accomplishment was only through great struggles, overcoming obstacles which cannot now be appreciated.

It has been frequently stated that, as regards speed, the locomotive has not kept pace with other railway improvements. Measured simply as speed this would seem true; but, on the other hand, when we regard the capacity to quickly generate great power, run long distances without stopping, and make great mileage before repairs are needed, the locomotive has made great progress. Locomotives which could generate and maintain 500 horse power were not common twenty years since. Now many of the passenger trains require from 800 to 1,000 horse power, and when we recall to mind that the measure of a horse power, as fixed by *Watt*, is equivalent to raising 33,000 pounds one foot high per minute, we may form some idea of the work accomplished. A few years since, 25,000 to 30,000 miles was considered a good yearly mileage for a locomotive; but now on some roads 10,000 miles per month are often run, and over 100,000 miles per year. In the wood burners of early times, a grate of eight to ten square feet area was sufficient, but when the change was made to coal, and more power required, the grates were enlarged, and in ordinary types of locomotives are now from fourteen to eighteen square feet, and burn from one to two pounds of coal per square foot per minute, to do which the blast must be very efficient.

From a long series of experiments upon many railroads, collecting and analyzing the escaping gases of combustion, I found that, as a rule, too much air was drawn through the fire-box to produce the most economical combustion of the coal. Some portions of bituminous coal escape partly as black smoke, and a general impression prevails that there is not sufficient air in the fire-box to burn them. This is not the case when the locomotive is running. The reason is that the gases have not sufficient temperature for the oxygen of the air to unite with them. For

First Table.

Analyses of the Products of Combustion on the P. W. & B. R. R., from Engine No. 40, *using Semi-bituminous Coal; Mail Train of* 8 *Cars. Gas collected between Chester and Wilmington, May* 3, 1878.

No. of Bag.	Vol. of gas in cubic centimetres used for analysis.	Percentage of carbon dioxide found.	Volume of unconsumed oxygen.	Percentage of carbonic oxide.	Volume of Nitrogen.	Percentage of unconsumed air in fire-box.	Estimated cubic ft. of air used for each lb. of coal. 70° F.	Estimated cubic ft. of air required for each lb. coal. 70° F.	Temperature of gas in smoke box.	REMARKS. No. Drivers 4, Diameter 66 inches, cyl. 16x24, exhaust nozzles 2, size 3 inches. Fire-box length ...., width .., depth ...., Steam pressure .... lbs.
6	100	8	10		82	55	242	156	700°	Black smoke. Up grade.
7	100	12	6.5		81.5	33.8	209	156	800°	Clear. Level.
9	100	10.5	7.5		82	41.7	221	156	750°	
10	100	10	8		82	44.4	225	156	760°	Light grade.

illustration, take a coal-oil lamp and light it—and it smokes, certainly not from want of air, but because it cannot raise the temperature to ignition. Put on the chimney, limiting the air supply to what can be raised to a proper temperature, and the smoking ceases.

The first table shows an analysis of the products of combustion. Out of the 21 volumes of oxygen in 100 volumes of air, in a few instances I found 17.6 united with the carbon to produce carbon di-oxide. But generally the results were much below, 10 to 12 volumes being about an average. In some cases the consumed oxygen was only 1.5 to 3. In the latter cases the waste of coal was very great, not only in the large amount of cinder ejected, but in the units of heat carried off by the excess of air passing through the fire-box and flues.

The second table gives the results of a series of experiments to trace the heat units in one pound of coal utilized in various locomotives. This is, as far as I know, the first of its kind ever presented. Each locomotive was run on its train at least 600 miles, and some were run 1,200 miles. The fuel and water consumed were measured, the gases of combustion analyzed, and the heat in the smoke-box measured. The headings of the columns are sufficiently explicit to explain fully the table. The striking contrasts with different locomotives show that much could be saved by proper attention to the blast and skilful firing.

The locomotive is still in a transitional state; the needs of tomorrow may not be met by the construction of to-day.

Most of the wrought iron used in the early constructions came from England, and also some of the locomotives. The latter were not adapted for the frail structures which the scanty means of a new country permitted to be built.

In 1830 only 23 miles of railway were in use; in 1840, 2,818; in 1850, 9,021; and in 1860, 30,635. The length constructed represented the comparative ease with which the difficulties were overcome.

The first locomotives of only seven to eight tons weight would draw two or three of the light passenger cars 15 to 20 miles per hour. The strap rails of one-half to five-eighths of an inch thick by two inches wide, laid upon the wooden stringers, after short service became loose, and sometimes would curl up through the car floors. There were many efforts to improve the form of the rails and at the same time make them cheap. Double-headed rails, continuous rails, and inverted U rails were used. Col. John Stevens, then president of the Camden and Amboy Railroad, invented in 1830 the present T rail. The quality of the

SECOND TABLE.

No. of Engine.	Ultimate heating value of one pound of coal, expressed in pounds of steam converted from the temperature of the feed water to that of the steam pressure carried; provided no heat was lost by radiation or carried away by the products of combustion or small coal and cinder thrown out of the smoke-stack.		Amount of water converted into steam, per pound of coal.		Amount of heat units carried away by the escaping products of combustion, expressed in pounds of steam.		Number of heat units lost by radiation and small coal thrown from the the smoke-stack, expressed in pounds of steam.		Total Quantity.	No. sq. ft. of grate surface.	No. of pounds of coal burned per hour per square foot of grate surface.	Average No. of cars per trip.
	Pounds.	Per cent	Pounds.	Per cent.	Pounds.	Per cent.	Pounds.	Per cent.	Per cent.			
62	11.80	100	8.66	73.3	1.87	15.9	1.27	10.7	99.9	14.6	50.3	6.2
50	11.81	100	6.46	54.7	2.63	22.3	2.72	23.0	100.0	14.6	79.2	6.6
74	11.84	100	7.57	63.9	2.14	18.1	2.13	17.9	99.9	15.9	63.5	9.1
56	11.83	100	8.26	69.9	2.27	19.2	1.30	10.9	100.0	15.9	54.1	9.1
41	11.84	100	7.50	63.3	2.18	18.4	2.16	18.2	99.9	14.4	55.5	5.5
63	11.82	100	7.94	67.2	2.69	22.7	1.19	10.0	99.9	15.9	53.2	5.5
40	11.82	100	7.14	60.4	2.34	19.8	2.34	19.8	100.0	14.4	69.8	7.1
17	11.81	100	7.56	64.0	2.16	18.3	2.09	17.6	99.9	14.6	63.5	7.9
57	11.81	100	5.72	48.3	2.57	21.7	3.52	29.9	99.9	17.0	88.1	10.4
73	11.81	100	5.89	49.6	2.40	20.3	3.56	30.1	100.0	15.9	84.9	10.2

P. H. DUDLEY, September, 1878.

iron used in his first rails was excellent; a section of one of them, after forty years of service, is here for exhibition. Another specimen is a piece of one of the early rails used on the Boston and Albany Railroad. The latter were only nine feet in length, and the ends cut in a diagonal form. A few lengths are now in a siding at Southville, Mass. During the last annual inspection, my car was run on this siding, and the deflections of the old rails were over twenty times greater than of their present 72-lb. rail. In the early times, each master mechanic had to fabricate most of his material for construction. He made and fashioned his springs as best he could, and is entitled to more credit than he received. The important and serious question was to keep his locomotives in running order; for if one made a round trip in the spring of the year without breaking down it was thought to be good luck. Men had to do many things unexpectedly and on short notice, and those who could not make the same thing do for a dozen purposes in an emergency were of little use. Short roads were being consolidated, slowly evolving the present great trunk lines; heavier and special types of locomotives, of thirty to forty tons, to draw more cars and faster trains had taken the place of the lighter ones. Under the increased tonnage, iron rails were giving way with unexpected rapidity, crushing at the joints, centres, and other places where the welds of the pile were imperfect. Thousands of tons of iron rails did not last three months, while two to three years' service was considered good for trunk lines. Rates for transportation were of necessity high to meet operating expenses. To improve the wear of the rail, phosphorus was put in the head, which after re-rolling would be mixed through the entire rail, making it brittle. The sections of the rail were made heavier, but without improving the results. Proper distribution and quality of iron were needed, as well as quantity.

During the civil war, the demands of the government for transportation of troops and munitions of war were so great and remunerative that the railroads prospered, but the benefits to them were small compared to those conferred upon the country. Steel tires for the driving wheels had replaced those of Lowmoor iron, giving many times increased service. Bessemer, in England, had long been working to make steel directly from the pig iron. As four to five per cent of carbon in it makes it weaker than wrought iron, while only three-tenths to one per cent makes it stronger, his idea was to remove a part of the carbon, leaving the rest to make the superior metal. In this new field of inquiry, he started with the assumption that crude iron contains about five per cent of carbon, which could not exist in the presence of oxygen at high temperatures without uniting therewith. So he blew air through the molten metal, thus producing intense combustion, burning out the excess of carbon. On a small scale, some steel was produced, but commercially it was not a success, and the iron masters denounced him. Bessemer, with that true inventive genius which is never baffled by obstacles as long as there is life, burned out *all* of the carbon, or decarbonized the iron, then added spiegeleisen to return the percentage of carbon and manganese required, and it became a great commercial success. The molecular change produced in the metal so improved it that it has permitted the extension of the railway system into new sections of the country, thus building them up instead of the country building up the railroads; and it has enabled lower rates of freight to be made than was then expected.

The prejudice against steel rails was strong, and this country is indebted to the late Alexander Holley for introducing and so improving the Bessemer plant, that to-day a ton of this steel can be made for less cost than a ton of wrought iron. To cheapen it so much has been at some expense of quality, and under heavy traffic the rails are now wearing more rapidly than those first used. The steelmakers are, however, not wholly responsible for this.

The paramount question of all roads is safety, and the breaking of a few rails led to the use of softer steel. It may seem a singular fact that more steel rails break the first year after being laid than afterwards. The causes of this are generally found to be due to injuries in straightening at the mills and careless handling before being laid—faults that should be remedied irrespective of the quality of the steel.

The results of some investigations have been interpreted as showing that soft rails wear the best. I have not found this to be the case, considering the physical properties. The chemical composition alone does not indicate the wearing properties.

Rail steel is not homogeneous or amorphous, but consists of aggregations of molecules of metal, having a delicate layer (possibly carbide of iron) joining one aggregation to another, and, as far as I have examined, the softer or coarser the steel the larger the aggregations; and in rolling they become elongated. In steel tires of driving and car wheels, some of these become detached, producing a series of irregularities as shown in our photographs. Soft steel rails wear in a similar manner, to some extent.

From the first practical operations of steam locomotion in the United States—about 1830—our railways have developed in extent and capacity, exceeding all other countries. 130,000 miles of main line are reported, and 26,000 miles more as additional track and sidings. Locomotives to operate them number

30,000, which, if placed in line, would reach from New York to Syracuse. The passenger, mail, express, and baggage cars would each extend about the same distance. The 820,000 freight cars coupled together would link New York to San Francisco.

To develop all these railways and build the necessary docks, coal chutes, elevators, warehouses, stations, and terminal facilities in the great cities, to cross the rivers and tunnel the mountains, have absorbed over one-seventh of the estimated wealth of this new and prosperous country. To manufacture all these locomotives, cars, wheels, springs, rails, and other specialties, enormous plants have been created, giving employment to thousands of artisans, miners, and laborers.

In operation the railways become great consumers of steel, iron, timber, paint, upholstery, glass, special tools, coal-oil, waste, etc. Armies of men are employed to run the trains, handle the freight and keep up the repairs of locomotives, cars, and track.

In a trip from New York to Chicago only a few employees can be seen, yet the number required to run the N. Y. C. & H. R. R. R. and the L. S. & M. S. Ry., exceeds the complement of the 25,000 soldiers of our standing army.

The movement of so many heavy and fast trains has demanded unlimited safety appliances, especially for the passenger service. The old system of hand braking has given way to the Westinghouse Air Brake system, by which the engineer who is dashing ahead at fifty miles per hour, may bring his train to rest in twice its length. It is not merely a convenience, but an absolute essential for present service.

The Miller platform, drawbar, and buffer have prevented thousands of cars from telescoping in collisions, and the consequent saving of life has been immeasurable.

Electric signals have been in use for many years on some of the eastern lines; and from long experience in remedying weak points are now quite successful. They are considered aids to the keen human intelligence required to move safely the numerous and frequent trains.

Theoretically, it would seem an easy matter to introduce a system of signals; but it is only developed by years of experience, and vast outlay of time and money. The system of interlocking switches and signals is extensively used at our eastern stations. This places a series of switches under the control of one man.

The greatest possible care is taken of the rolling stock; trains are inspected, wheels examined, boxes oiled, and axles are only allowed to run from 80 to 100,000 miles before being removed, that being considered the limit of safety for passenger service.

Axles bend at each revolution of the wheels, and it is only a question of time when they will become weakened.

The telegraph is now an absolute essential for the safe movement of trains, and on some roads the train despatcher directs the movements of each train on his division.

A few years since, a slow rate of ten to twelve miles per hour was thought to be the most economical for freight trains, but on good tracks of steel rails this is not the case. In 1875–'76, in a series of experiments I made with my Dynagraph on the L. S. & M. S. Ry., I found it required less fuel to run the stock trains eighteen to twenty miles per hour than it did the freight ten to twelve miles with the same engine. This was a revelation; but the fact was found to repeat itself in different experiments. At the slow speed the locomotive must work harder to control the train over slight ascents; it ejects more coal from the smoke-stack, and it draws in a greater supply of air through the fire-box than can be utilized, which, therefore, becomes wasteful by carrying off heat. The speed was afterwards increased by this road, and the increase found more economical in fuel; the carrying capacity was greater with the same equipment; and the hours of labor for each trip were shortened. Equipping the freight trains with power brakes will lead to higher speed; but the cars should be mounted on better springs than at present, for their almost dead loads are harder on the track than heavier loads on more elastic springs.

On opposite tracks used by the same locomotives and cars, the east bound, on which the loaded cars go, shows more wear than the track over which they return empty or lighter loaded.

The work of our railways is beyond any real conception. In 1884, 334,814,529 passengers were carried, and 390,074,749 tons of freight.

The rates of freight per ton per mile on one of the great trunk lines have gradually decreased from $1.88 in 1870, to $\frac{68}{100}$ of a cent in 1885, and the profit above operating expenses from $\frac{73}{100}$ of a cent to $\frac{14}{100}$ of a cent, during the same period. At this low rate one ton of freight must be hauled seven and one-seventh miles to earn one cent. Such low rates are not a benefit to the country, for they are below the actual cost, in the long run, of doing the business, and beyond narrow limits do not increase the volume carried. Some one must pay the cost of transportation, either the patrons or stockholders. When the latter bear the expense it quickly affects the entire business of the country, transportation being so directly connected with most industries.

Railway officials are just beginning to appreciate how a slight difference in the condition of the track makes a great difference in the cost of operating. All roads desire good tracks, and some roads are gradually improving them. The Boston and Albany have spent large sums of money on their track for a number of years, and in the past two years have reduced their average deflection per rail over one-eighth of an inch. I have run my "Dynagraph and Track Inspection Car" over their tracks three or four times a year to mark deflections, many of which would escape the eye of the trackman.

Their gross income in 1883 was about $8,540,000. In 1884 it fell short $392,000, and in 1885, $510,000 from the year before. The improvement in their tracks has been so great, and the operating expenses so reduced thereby that in these two years their net income has only fallen $36,000 below that of 1883.

Of the improvements made in passenger travel, I hardly need speak. The parlor, sleeping, and dining-cars give comfort and luxury to travel. Chicago, 1,000 miles from New York, is only twenty-five hours in time. One can sleep and eat on the same train, and get a daily paper. The difference between all this and the inception in 1830, shows the progress of our great railway system of 1886.

DISCUSSION.

The PRESIDENT, PROF. TROWBRIDGE, DR. HUBBARD, MR. McDONALD and others participated in the discussion.

In reply to inquiries, MR. DUDLEY made the following remarks.

One cause of the breaking of ordinary iron or steel axles is due to the more or less granulated or crystalline structure. A thin lamina seems to join one granulation to another; the latter are coarse or fine according to the quality of the metal and the method of manufacture. When the axles are repeatedly and quickly strained, even much below the elastic limits, the cohesion of the laminæ is lessened and they eventually separate along the planes of the granulations. From examination of a number of broken axles, the planes appear to increase in size, up to a certain extent, the longer the axle is used. One of eighteen months' service has larger planes apparently than one of only twelve months' use. Examination with the microscope shows that more of the laminæ which are at right angles to the planes are broken, and one or two and sometimes more planes are joined to form one face.

Stone ballast is not quite so elastic as good gravel, but it is not so much affected by water, and is much freer from dust. In England it is very extensively used. Every few years where the traffic is heavy it must be reworked to remove the cinders ejected by the locomotives.

The weight of rails is increasing. The first steel rails, in 1863, weighed 56 lbs. per yard. The weight soon increased to 60 lbs., then to 65 lbs. and 67 lbs. about 1870. Many of the New England roads are now using 72 lb. rails. The section here exhibited weighs 80 lbs. per yard, and is one pattern used by the N. Y. C. & H. R. R. R. In England the rails weigh from 70 to 90 lbs. Large quantities of 80 lbs. are used. The double headed rail is very common, and it is laid in cast-iron chairs, one upon each tie, the latter being about three feet apart from centre to centre. Some roads use flat-bottom rails similar to those employed in this country.

The weight of locomotives is increasing. Many for passenger service now weigh forty-five tons exclusive of the tender.

The adhesion of the locomotive is, on dry rails, over one-third the weight upon the drivers, but it decreases to about one-fourth or one-fifth on a slimy rail. A wet rail washed clean decreases the adhesion very little.

The dynamometrical curve indicating the power used in starting and running a train, would at first, in starting, be the full traction the locomotive could exert—from about 12,000 lbs. to 16,000 lbs.; the latter being for the largest passenger locomotives. The curve falls rapidly at first as the train gains motion, then more slowly; and finally becomes quite uniform in height for a definite speed and level track. For a train of ten cars at a speed of fifty miles per hour the dynamometer shows a tension on the draw-bar of 3,000 to 3,200 pounds. To attain this speed requires usually a run of four or five miles. While the tension upon the draw-bar is not so great for long trains as many persons suppose, the consumption of power is, however, far greater. A train of the size above noted would require from 500 to 600 horse-power, and some of the faster trains consume 800 to 1,000 horse-power.

Very few iron ties have been used in this country, and the experience is limited. In Germany they have been extensively used; also in India, and to some extent in England.

Paper wheels are in extensive use under passenger cars. In regard to economy in their use there is some difference of opinion; but their greater safety is unquestioned.

The President referred to the rail invented by Mr. Booth, which had been exhibited many years ago to this Society. Of this rail the base, web, and a small head were of iron. Over the small head a cap of crucible steel was rolled, which gave a hard wearing surface combined with a tough iron base. Many thousand tons of these rails were used. But about this time Bessemer steel was introduced and superseded all other steel rails. In consequence, Mr. Booth realized very little from his invention.

February 8, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the Chair.

A large audience present in the east lecture room of the Library Building, Columbia College.

The third lecture of the Popular Lecture Course was delivered by DR. JOHN S. BILLINGS.

Subject: THE USES AND DANGERS OF MICRO-ORGANISMS.

(Illustrated by the cultivated organisms, charts and lantern-views.)

February 15, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Twenty-five persons present.

PROF. JOHN K. REES read the following papers:

I. A NEW ELECTRIC WINDING-APPARATUS FOR CLOCKS.

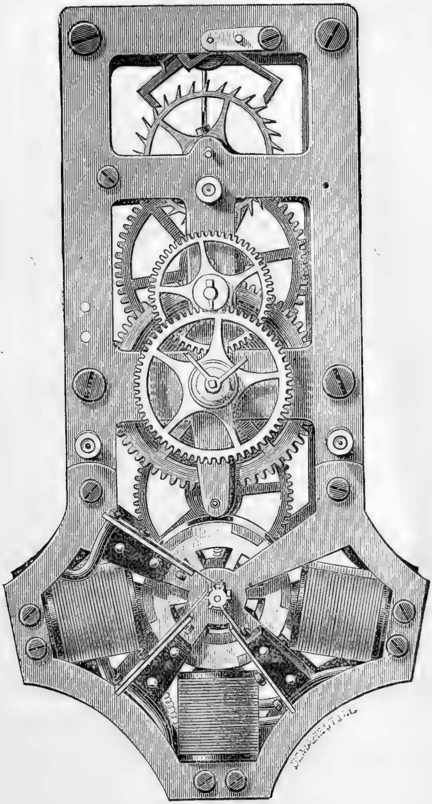
Accurate time is necessary for most of the scientific work of the observatory. By star observations the error of a clock can be determined to within about one-fiftieth of a second; but during cloudy weather observations cannot be made, and then the clock error must be determined by adding to the error at a known date the accumulation of error due to the clock's rate. If this rate is constant and can be depended upon, such an error will be an accurately determined one; but if the clock's rate is not constant, such an error may be far from the truth. It is important, therefore, that the observatory should have a clock constructed in such a way as to make its rate constant or very nearly so. It was long thought that the practical solution of the problem of the construction of a clock of constant rate would be found in the adoption of a pendulum which would not alter its length with the temperature, and so we find Graham, Harrison and others devising forms of compensated pendulums in which the downward expansion due to heat, increasing the length of the pendulum, was counteracted by an equal upward expansion, shortening the pendulum by the same amount. But after these many forms of compensated pendulums were found not to thoroughly compensate, attention was turned to the question of how far the temperature of a room could be kept at a certain fixed point. This question has been solved by placing the clock, provided with compensated pendulum, inside of two or three cases, the whole being established in a room under the ground, which room is kept at a fixed or very near to a fixed temperature. Such arrangements were found to give very much better clock rates than any other; but it was observed that the clock rate was still not constant. Investigation showed that the changes in the rate were undoubtedly due in part to changes in the density of the air through which the pendulum bob swung.[1] Sir George Airy devised an apparatus which is still in use at the Greenwich Observatory, England, for the purpose of automatically making the correction rendered necessary by the changes in the barometric pressure.[2] But here again it was fcund that although the apparatus did largely correct the changes of rate due to variations of density of the air, yet there was a residual correction necessary. No one has yet succeeded in showing how to eliminate this residual error, although attempts have been made; and in some recent apparatus there is promise of a closer approach to complete success. Some years ago, Mr. Ballou, of Connecticut, invented an electric winding apparatus which he adapted to several astronomical clocks. This apparatus was so arranged that the winding was automatic, and in a test made at Cambridge, Mass., during a six weeks' trial of one of these clocks, "it was found to run better than the Harvard College Observatory's best clock." In a clock furnished by Mr. Ballou to parties in Washington, there was adopted a form of *air-tight* case which completely surrounded the apparatus, and therefore kept the density of the air inside of the case always at the same point. In this apparatus of Ballou's there was considerable complication, and it was quite expensive.

In the form which we describe to the Academy to-night, weights are done away with entirely, and in their place a spring is employed. This spring is coiled on the arbor of the hour wheel; in unwinding it delivers its power direct to the hour hand. During one hour the revolution of the hour wheel brings a "toggle" piece to a position where an electric contact is made, when a current from a single Leclanché cell passes through a small electric motor attached to the lower part of the clock

[1] A decrease of one inch in the barometer reading increased the daily gaining rate of the Greenwich clock by about three-tenths of a second.

[2] See *Nature* for April 1, 1875. Lockyer's *Star-Gazing*, p. 194. *The Observatory* for November, 1885, p. 366.

works. This machine winds up the spring one revolution, just what was unwound during the hour. In the winding the direction of the motion is in the direction of the hands of the clock,



so that there is no lost power. As the spring drum reaches the end of its revolution, a small finger projecting from the face of the drum breaks the contact and the winding ceases. The advantage of this form, invented by Mr. C. H. Pond, of New York City, is that it can be attached to many forms of ordinary clocks, and can also be adapted to the more delicate clocks used in the observatories. As to how constant a rate an astronomical clock would have when provided with such a winding apparatus and impelled by a spring instead of by weights, we cannot say. We hope to be able soon to make some experiments on the rate of a fine clock provided with this new apparatus. Such an arrangement of apparatus could be put into an hermetically sealed case and placed in a room with a fixed temperature, and be beyond the reach of both variations of rate due to temperature, and those due to barometric pressure and to moisture.

The inventor claims that the electro-mechanical clock has the following advantages over the ordinary weight or spring clock as made hitherto:

1. The friction and wearing parts are reduced to a minimum.
2. The winding is so arranged that a uniform tension is kept on the train during the process of winding.
3. A given force or propelling power exerted on the hour arbor actuates the escape-wheel with a large per cent more force than is attained in the ordinary clock driven in the ordinary way.

These advantages are secured in the following way: The wheels and arbors below the hour or centre arbor are removed from the clock. In their place a small electric motor is substituted. This little motor connects with a spring barrel on the centre arbor, which incloses a spring six feet long and three-sixteenths of an inch in width and six-one-thousandths of an inch in thickness. This spring at its inner end is attached to the arbor, and at the outer end to the periphery of the spring barrel. The spring is wound around the arbor a great many times, but not wound so close as to produce friction between the coils; and being attached to the hour arbor, it follows that the inner end will unwind one turn in one hour. By a simple attachment the electric circuit is made to pass into the motor already referred to, which quickly and silently carries the spring barrel around once (being loose on the shaft), and the outer end of the spring attached to its periphery with it. Upon the completion of the revolution of the spring barrel, as described, the electric circuit is broken and the motor stops. By this arrangement, it will be observed that the inner end of the spring always has a motion from left to right, or in the direction of the hands' motion, and the outer end of the spring a motion in the same direction, each hour.

Now, since the winding is done in the same direction as the unwinding of the inner end, and the spring is so wound originally as to avoid friction between the convolutions, it follows that the tension upon the train is absolutely uniform at all times, whether the outer end of the spring is at a point of temporary rest, or is being carried around the arbor at the hour as above described.

By actual experiment, it is found that to obtain a given force at the escape-wheel, it is only necessary to apply a power in this manner at the centre arbor equal to less than one-forty-sixth part of that used in the ordinary clock. The train work is thereby shortened one-half, and the friction on the remainder reduced in the proportion above stated.

Experiments seem to prove that a motor as constructed for this purpose can be run for one year at an expense of less than twenty-five cents. A common clock constructed on this principle has been found to keep as accurate time as one of the higher grades, with gravity escapements, etc., run by the old methods.

It may be not unprofitable to give a more detailed explanation of the circuit-making and breaking apparatus.

The electric motor is normally out of circuit, but at stated intervals, by the operation of the clock itself, the circuit is completed, and the motor is thus set in motion. But, to be more exact, we will give a general description of the mechanism employed in the clock. Upon the centre arbor there is placed a loose "toggle" or arm, between the hour wheel and the wheel carrying the spring box. At one side of one of the frame plates is secured an insulated spring connector, the free end of which extends to the centre of the frame and is within reach of the "toggle" when the same has been brought to a perpendicular position by means of a pin projecting from the hour wheel. When the hour wheel has thus brought the "toggle" to an upright position and in contact with the insulated spring connector, the circuit is completed through the motor, which at once commences to rotate the spring box one revolution from left to right, or in the direction that the hands move. The spring-box wheel also carries a projecting pin, but set at a less distance from the axis than the other pin. Now, as the motor continues to rotate the spring-box wheel while the spring connector is resting upon the "toggle," it follows that as soon as there has been one revolution of the spring-box wheel, the projecting pin upon the same will press the "toggle" forward and out from under the spring connector, thereby breaking the circuit, and stopping the motor. This arrangement prevents the possibility of the clock's running beyond the regular limit for winding, and prevents the motor, when once set in operation, from performing more than the work required. The operation of the clock causes the circuit to be established, while the motor utilizes its own power to interrupt the circuit.

[A common clock provided with the Pond winding-apparatus was exhibited.]

II. ON THE NEED OF A NORMAL TIME SYSTEM FOR OBSERVATORIES.

Any observatory can, when supplied with a good transit instrument and a fine clock, determine very accurately the error of that clock at the time the observations are made, but owing to the non-constant character of the rate of the clock it is impossible to calculate, with the desired accuracy, the error of the clock after the lapse of several days, during which, for any reason, observations have not been taken. Cloudy weather often prevents, for many days, the taking of observations.

The people of this country have been educated to an appreciation of accurate time—time which is correct to within less than a second, or even one-half a second. Time balls are dropped in many of our large cities, and the error of the "drop" is usually published the next day in *tenths* of seconds. Jewellers depend for rating watches, etc., on the close accuracy of the "time signals" received by them over the wires of some time distributing company. Scientific observers often are compelled to rely on the stated errors of the telegraphic time signals sent over considerable lengths of line.

It becomes necessary, therefore, for those managing time systems to be very careful in sending out "time signals," and in stating the errors of those signals.

In the New York City Telegraphic Time Service, of which Mr. Jas. Hamblet is the manager, the central clock distributing the signals throughout our city is now checked by daily chronographic comparisons with several observatories. Several years ago these comparisons were made with the observatories at Harvard, Yale, Alleghany, and Washington, all of which have fine time systems in operation. The discrepancies between the calculated errors of the New York clock, as determined from the several comparisons, were often quite large, in some cases approaching to five seconds.

These comparisons were discontinued for several years, but recently have been undertaken again. My attention was drawn to the desirability of the continuance of these comparisons by the impossibility of making my time observations agree with the stated errors of the New York system—founded only on the standard noon signal sent from the Washington observatory.

On my calling Mr. Hamblet's attention to the matter, he offered to take up again the old system of many comparisons, and has sent me the following records.

All the comparisons except those for Columbia College were made by Mr. Hamblet at the rooms of the time system. These comparisons for Columbia College were made on our own chrono-

Daily Comparisons of the New York Standard Clock.

Date. 1885.	CAMBRIDGE, Comparisons at 5 P.M.		WASHINGTON, Comparisons at noon.		ALLEGHANY, Comparisons at 5 P.M.		NEW HAVEN, Comparisons at 5 P.M.		COLUMBIA COLLEGE, Comparisons usually made at night in the observatory	
	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.
Oct.										
22	..	..	0.24	..	..	..	..	..	..	..
23	..	..	..	0.05	..	..	..	..	..	..
24	..	..	0.03	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	..	..
26	1.30	..	..	0.41	..	..	..	1.41	..	..
27	1.80	..	..	0.45	0.40	..	..	1.95	..	..
28	..	..	..	0.57	..	..	..	..	..	..
29	..	..	..	0.36	..	..	..	..	..	..
Dec.										
1	..	0.75	..	0.63	..	0.62	..	1.95	..	..
2	..	..	..	0.61	..	..	..	..	..	..
3	0.05	..	..	0.70	..	0.55	..	2.35	..	..
4	..	0.45	..	0.80	0.07	..	..	2.52	..	..
5	..	..	..	0.80	..	..	..	2.42	..	..
6	..	..	..	..	..	..	..	1.07	..	..
7	..	..	0.17	..	..	..	..	..	..	..
8	..	..	0.15	..	..	..	..	..	..	..
9	..	..	0.12	..	..	..	..	..	..	..
10	0.75	..	0.36	..	0.65	..	..	0.65	..	..
11	1.30	..	0.52	..	1.10	..	..	..	..	..
12	..	..	0.20	..	..	..	..	..	..	..
13	..	..	..	..	..	..	..	..	..	..
14	..	..	..	0.77	..	..	..	..	..	..
15	..	..	..	0.76	..	..	..	..	..	..
16	0.93	..	..	0.81	0.51	..	0.13	..	..	..
17	1.60	..	0.35	..	1.45	..	..	..	..	..
18	..	..	0.95	..	..	..	..	..	..	..
19	3.05	..	0.98	..	1.51	..	1.60	..	..	..
20	..	..	..	..	..	..	..	..	..	..
21	3.15	..	1 15	..	1.75	..	1.05	..	2.79	..
22	2.76	..	1.05	..	1.45	..	0.18	..	3.12	..
23	..	..	0.78	..	..	..	..	..	3.09	..
24	2.85	..	0.45	..	0.98	..	..	1.25	..	..
25	2.10	..	..	..	1.52	..	..	1.22	..	..
26	..	..	0.92		..	..	..	..	..	..
27	..	..	..	..	..	..	..	..	..	..
28	1.21	..	..	0.03	2.12	..	..	1.08	2.66	..
29	..	..	0.57	..	1.96	..	..	0.87	3.11	..
30	..	..	0.71	..	..	..	..	..	3.23	..
31	..	..	0.62	..	1.25	..	..	..	2.00	..

Daily Comparisons of the New York Standard Clock.

	CAMBRIDGE, Comparisons at 5 P.M.		WASHINGTON, Comparisons at noon.		ALLEGHANY, Comparisons at 5 P.M.		NEW HAVEN, Comparisons at 5 P.M.		COLUMBIA COLLEGE, Comparisons usually made at night in the observatory.	
Date. 1886.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.	The N. Y. Clock is Fast Seconds.	The N. Y. Clock is Slow Seconds.
Jan.										
1	..	..	.	..	..	..	..	..	..	..
2	..	..	0.20	..	..	..	..	..	1.65	..
3	..	..	..	..	..	..	..	..	..	..
4	1.74	..	0.05	..	..	..	..	0.45	1.22	..
5	1.15	..	..	0.49	..	0.08	..	0.89	0.58	..
6	0.65	..	..	0.83	0.68	..	..	0.68	0.49	..
7	0.45	..	..	0.45	1.60	..	..	0.92	0.66	..
8	1.10	..	..	0.45	1.55	..	..	1.55	1.67	..
9	..	..	..	.	..	..	..	..	..	..
10	..	..	..	..	..	..	..	..	..	..
11	..	1.25	..	0.26	2.15	..	..	3.65	1.01	..
12	..	1.15	0.09	..	2.36	..	.	3.55	2.24	..
13	0.48	..	0.02	..	1.75	..	..	3.75	2.66	..
14	0.97	.	0.55	..	1.36	..	..	3.78	3.33	..
15	0.91	..	0.71	..	1.69	..	..	3.90	3.99	..
16	1.20	..	0.45	..	1.76	..	..	4.15	2.31	..
17	..	..	..	..	..	..	..	..	..	..
18	1.22	..	0.80	..	1.61	..	..	1.97	1.98	..
19	..	..	..	..	..	..	..	..	1.99	..
20	..	..	0.70	..	..	..	..	..	1.68	..
21	1.10	..	..	..	1.37	..	2.65	..	1.43	..
22	..	..	0.50	..	..	..	..	..	..	..
23	1.10	..	0.37	..	0.45	..	3.95	..	0.69	..
24	..	..	..	..	..	..	..	..	..	..
25	0.37	..	0.02	..	1.55	..	4.45	..	..	..
26	0.90	..	0.14	..	1.25	..	3.78	..	..	..
27	0.75	..	0.10	..	..	..	3.98	..	..	..
28	0.40	..	0.23	..	0.55	..	4.45	..	..	..
29	0.52	..	0.05	..	0.10	..	4.85	..	..	..
30	..	0.10	..	0.23	..	0.38	5.15	..	..	..
31	..	..	..	..	..	..	..	..	..	..
Feb.										
1	0.50	..	0.75	..	2.45	..	6.65	..	..	..
2	0.75	..	1.02	..	2.22	..	6.85	..	..	..
3	..	..	0.86	..	..	..	..	..	..	..
4	1.21	..	0.47	..	2.20	..	7.22	..	..	.
5	..	..	0.41	..	..	..	..	..	..	..
6	..	..	0.40	..	..	..	..	..	..	..
7	..	..	..	..	..	..	..	..	..	..
8	0.02	..	..	0.60	0.06	..	5.11	..	..	..
9	0.21	..	..	0.74	0.55	..	4.63	..	..	0.39

graph in the observatory. The beats of the standard clock of the time system were recorded on the chronograph along with our clock-beats and, when star observations were being made, in the middle of the set of observations.

In examining these tables we note large discrepancies. These discrepancies are too greatand varying to be caused wholly by differences in the resistances in the electric circuits. Some part of the differences is undoubtedly so caused, but we believe the larger part due to careless sending of the signals, and unwarranted assumptions as to clock rates.

In order to get rid of such discrepancies as far as possible, some time ago the following scheme was drafted at Columbia College. An interested friend agreed to subscribe the money necessary to put the scheme into operation, and President Barnard was heartily in favor of the plan. As yet it has not been possible to secure the co-operation of the surrounding observatories :

A Normal Time Service for Observatories.

The main features of the plan suggested by Mr. J. Rayner Edmands, of Harvard College Observatory, at the Montreal meeting of Am. Assoc. Adv. Science, are:

1. A *normal* clock, whose signals are sent daily to each co-operating observatory.

2. A system of mailing and telegraphing, by which each observatory receives the results of observations made at the others, relative to the errors of the normal signals.

3. Such work at the central bureau as shall tend to improve and expand the system.

The complete development of the first feature would involve the erection of a pair of clocks as alternates, with all practicable refinements to secure uniformity of rate. Automatic apparatus for making comparisons might be added.

To carry out the second feature, each determination of the error of the signals would be mailed directly to such observatories as it would thus reach in time to be useful. It would also be telegraphed to any observatory at which it promised to be particularly valuable, judging from weather reports. The central bureau would receive all results, discuss them systematically, and keep the observatories posted to as late a date as may be. The third feature covers the discussion of systematic discrepancies between the several observatories; experiments to guard against error in transmitting signals; the printing of blank forms for mailing; improvements in apparatus, etc.

By this plan each observatory has the benefit of an additional normal time-piece, while there is distributed a *scientific time-*

datum for precise purposes. Each also receives, 1st, a careful discussion of all observations up to within a few days; 2d, later returns from adjacent observatories; 3d, telegrams during storms from observatories having better weather.

February 22, 1886.

SEVENTIETH ANNUAL MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Twenty-one persons present, in the regular meeting room of the Society, Hamilton Hall, Columbia College.

The Report of the Recording Secretary, PROF. H. L. FAIRCHILD, for the past year, is summarized as follows:

The Council has held twelve meetings, and the Academy has held thirty-four, including six popular lectures. The average attendance at the meetings of the Academy, exclusive of the six popular lectures, was thirty-eight. The number of formal or announced papers read is twenty-six, and they may be classed as follows: Mineralogy, 4; Geology, 3; Applied Geology, 3; Palæontology, 2; Zoology, 2; Philology, 2; Engineering, 2; and one each upon Astronomy, Archæology, Agriculture, Botany, Electricity, Geodesy, Mechanics, and Meteorology. The number of informal communications is large, and they cover a wide range of scientific topics.

The roll of members has been revised, and now numbers 302 resident members, including 71 Fellows. During the year seventeen persons have been elected, thirteen have qualified, and four resignations have been accepted.

The Corresponding Secretary, PROF. A. R. LEEDS, reported the election, during the year, of seven corresponding members, who had each accepted the honor.

The Treasurer, DR. JOHN H. HINTON, made the following report:

New York Academy of Sciences in Account with John H. Hinton, *Treasurer.*

From February 23, 1885, *to February* 22, 1886.

Dr. *Disbursements.*		*Receipts.*	*Cr.*
Gregory Bros., Printing	$817 93	Balance on hand, February 23, 1885	$418 59
Trow Printing Co.	406 85	Annual dues	1,160 00
Industrial Printing Co.	153 71	Initiation fees	80 00
Prof. D. S. Martin, editing Annals	100 00	Subscriptions to Annals	194 00
" " " expenses Pub. Com.	125 96	Sale of publications	74 05
J. H. Bufford's Sons, printing	50 00	Interest on invested funds	176 00
Lecture expenses	109 35		
John Cornelsen, collecting	102 00		$2,102 64
Janitor, postage, and lecture expenses	42 50	Balance in Treasury	91 18
Janitor	26 00		
E. L. Peterson, work, postage, and freight	21 34		
A. Woodward, work on library, expenses, etc.	17 82		
Dr. O. P. Hubbard, Record. Sec'y, postage, etc.	4 15		
Prof. H. L. Fairchild, " " " "	9 13		
Postage and express	4 72		
John H. Hinton, postage, etc	20 00		
	$2,011 46		$2,011 46

The Librarian, DR. A. A. JULIEN, reported that the Library now consists of

Bound Volumes	4,335
Unbound Volumes, Pamphlets, etc	3,938
Entire Library	8,273

The present yearly increase of the Library is, in volumes and pamphlets, about 1,100. The Library is at present in the American Museum of Natural History, but the subject of its removal to Columbia College Library Building is still under consideration.

In reply to inquiry, the PRESIDENT stated that a formal notice terminating the contract with the American Museum of Natural History, relating to the Library of the Academy, was sent August 14, 1885. That a formal reply had been received stating that the Library would be at the disposal of the Academy upon the expiration of the year's notice, August 14, 1886. Negotiations, however, had not ceased.

The Chairman of the Publication Committee, PROF. D. S. MARTIN, reported that Vol. III. of the TRANSACTIONS had been published during the year under the editorship of DR. A. A. JULIEN; that Vol. IV. is now being edited by DR. N. L. BRITTON; and that Vol. V., the current volume, is being issued monthly under the editorship of the Recording Secretary.

Of the ANNALS, Nos. 7, 8, and 9 had been published, No. 10 is in press, Nos. 11 and 12 are required to complete Vol. III.

A new list of members, and of Societies with which the Academy exchanges publications has been printed, along with a new edition of the Constitution and By-laws.

The Treasurer was authorized to place upon the bills for dues a notice, that after May 1st, an additional sum of fifty cents would be added to each bill to cover the cost of collecting by messenger.

The PRESIDENT announced the death of DR. A. C. POST, and, upon adopted motion, appointed as a memorial committee, DR. J. H. HINTON, DR. O. P. HUBBARD, and PROF. D. S. MARTIN.

The annual election resulted in the choice of the following officers for the coming year:

President, J. S. Newberry.

First Vice-President, O. P. Hubbard.

Second Vice-President, W. P. Trowbridge.

Corresponding Secretary, A. R. Leeds.

Recording Secretary, H. L. Fairchild.

Treasurer, J. H. Hinton.

Librarian, A. A. Julien.

Councillors, J. A. Allen, P. H. Dudley, A. A. Julien, D. S. Martin, J. J. Stevenson, C. Van Brunt.

Curators, B. G. Amend, N. L. Britton, B. B. Chamberlin, C. F. Cox, G. F. Kunz.

Finance Committee, L. E. Chittenden, Henry Dudley, Thomas Egleston.

Dr. J. B. Holder remarked upon

THE OCCURRENCE OF A LARGE MARINE VERTEBRATE OF UNKNOWN FORM ON THE SHORE OF FLORIDA.

Before proceeding to the description of the remains of this animal, it may be well to briefly record in our proceedings the several more important statements and facts in connection with the subject of the so-called "sea-serpent."

When Sir Charles Lyell asked Colonel Perkins, of Boston, Mass., if he had heard of the "sea-serpent," he replied, "unfortunately, I have seen it." His reply shows the effect of the ridicule which has been showered upon the subject. But many individuals of assured integrity and learning, who were fitted to judge fairly and to describe accurately what they saw, have been eye-witnesses and narrators touching this interesting theme. Such testimony seems to establish the fact of the existence of some marine creatures of unfamiliar form and unusual proportions, which appear to be essentially different from any known living species.

There are on record several notable statements relating to the occurrence of such animals off our North Atlantic coast.

Without referring to the tales issued at each recurring season from the newspaper press, and leaving aside several more or less authentic statements from sea-faring people, both in this and other countries, we may assume that a proper, truthful history of this subject should be based upon the documentary evidence, affidavits, etc., of the several gentlemen of Boston and Lynn, Mass., who saw what they describe.

The Records of the Linnean Society, of Boston, Mass., show that a committee was appointed to report upon the "strange appearance at Nahant." The "monster," they say, "was from eighty to ninety feet in length. His head, usually carried about two feet above water, was of a dark-brown color. The body had thirty or more protuberances, resembling a string of buoys. Its motion was very rapid, faster than that of a whale, being a mile in three minutes, or faster, leaving a wake behind. Mackerel and other fishes were seen jumping out of water many at a time as he approached. . . . A skilful gunner fired at him from a boat, and having taken good aim, felt sure he must have hit him on the head. The creature turned toward him, then dived under the boat, and reappeared a hundred yards on the other side."

Mr. Amos Lawrence, one of the most notable merchants and citizens of Boston, gives similar testimony. Col. Harris, commanding at Fort Independence, in Boston harbor, stated that such a creature had, about the same time, been reported by his sentinels as swimming around the fort in the early hours of morning.

Several other prominent Boston and Lynn names are recorded in this connection, but the following is, perhaps, most important for the circumstantial details :

James Prince, Marshal of the district, writes to Judge Davis:

"MY DEAR JUDGE.—I presume I have seen what is generally called the sea-serpent. . . . I will state that which, in the presence of more than two hundred other witness, took place near the Long Beach of Nahant on Saturday morning last.

Intending to pass a few days with my family at Nahant, we left Boston early on Saturday morning.

On passing near the Beach, I was informed that the sea-serpent had been seen the evening before at Nahant Beach, and that vast numbers of people from Lynn had gone to the Beach that morning in hopes to see him.

I was glad that I had my famous mast-head spy-glass with me. On our arrival at the Beach we associated with a considerable collection of people on foot and in carriages.

Very soon an animal of the fish kind made its appearance. Its head appeared about three feet above water. I counted thirteen bunches on his back. My family thought there were fifteen. He passed three times at a moderate rate across the bay, but so fleet as to occasion a foam in the water. My family and myself judged it to be about fifty or sixty feet long. . . . As he swam up the bay we, as well as other spectators, moved on, and kept nearly abreast of him. He occasionally withdrew himself under water. The time he kept under was, on an average, about eight minutes. Mrs. Prince and the coachman, having better eyes than myself, were of great assistance to me in marking the progress of the animal. They would say: 'He is now turning,' and by the aid of the glass I could distinctly see this movement. I had seven distinct views of him from Long Beach, and at some of them the animal was not more than a hundred yards distant.

After we had been at the Beach about two hours, the animal disappeared.

On passing to the other Beach, called Little Nahant, homeward, we were again gratified beyond even what we saw in the other bay, which I conclude he had left in consequence of the number of boats in the offing in pursuit of him. We had here more than a dozen different views of him. Once he was so near as to cause the exclamation: 'Oh, see his glistening eye!'

One of the most trustworthy witnesses as to the proportions and movements was Mr. John Marston, of Swampscott, near Lynn and Nahant. He judged the creature to be over eighty feet long. He says: "I saw the whole body, not his wake." The sea was calm, and the creature very near to spectators.

One of the survivors of this remarkable period, Mr. N. D. Chase, of Lynn, Mass., kindly gave the writer a written statement of his view of the creature at this time, which was in August, 1819. He 'saw him repeatedly at a distance of not more than one hundred yards.'"

We have now to add another and most important element to this history—the fact of the actual finding of a carcass on the Atlantic shore, with proportions similar to those described in the above statements.

During the spring of 1885, the Rev. Mr. Gordon, President of the United States Humane Society, while visiting the Florida coast, chanced to be a passenger on a small sloop whose anchor became "foul" by entanglement with some great carcass. After considerable delay, the creature was disintangled, and towed in shore.

Mr. Gordon immediately proceeded to have the carcass hauled upon the beach, and placed beyond high-water mark. The more important features were carefully noted by Mr. Gordon, and we have to express acknowledgments for his very courteous communication of the facts as he saw them.

The entire length of the carcass was forty-two feet. Its diameter or greatest depth through the thorax was less than two feet. The whole was in the condition of maceration, the integuments being entirely absent, the flesh tough, and of a pinkish hue.

The ribs were distinctly made out, and to the observer the entire thorax and abdomen were something less in bulk than those of an ox. The head was absent. The neck was represented by only two or three feet in length. The long caudal portion appeared to be covered by little but ligamentary structure, which presented sharp-cutting tools. It exhibited something of the aspect of a saurian's tail, the vertebræ occupying most of the structure. There was an opening into the abdomen from whence the intestines protruded. Ragged remains of distinctly-determined forelimbs or flippers were noticed. There was no appearance of pelvic development. The captain of the schooner *Mystery*, commanded by Captain Hiscock, of St. Lucia, Florida, writes me: "The carcass was found near shore, about one hundred and twenty-five miles south of my place of residence, at New River inlet, Florida (on the east coast), about the first of May."

Chas. Coman, keeper of Fort Lauderdale Station, U. S. L. S.S. states: "The body had neither flukes nor head. The whole surface was so excoriated by grinding on the beach and by fishes that it looked like a mass of strings, glistening white, and so tough I could scarcely pierce it with my bowie. There was an opening in the abdomen through which the entrails protruded. The latter, like the rest of the carcass, were torn and worn by the sand. As the most important part, the skull, was wanting, I made no attempt to save the skeleton."

Mr. Gordon used all the facilities in his power to secure the remains. The carcass was hauled up the beach and buried, but it is probable that subsequent severe storms carried it away.

PRESIDENT NEWBERRY remarked that he could testify from personal observation that there are in the ocean some large animals yet unknown to science. Once when becalmed in mid-ocean he had seen from the crosstrees a cylindrical snake-like animal pass near the ship just below the surface. It was twenty feet or more in length, and perhaps twenty inches in diameter in the middle. It swam rapidly and steadily, apparently by means of a caudal fin. It did not come to the surface to breathe, at least for half an hour; and was therefore probably an Elasmobranch fish, but certainly not one which has been described.

March 1, 1886.

REGULAR BUSINESS MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

One hundred and thirty persons present, in the east lecture room of the Library Building, Columbia College.

The following persons were elected Resident Members :

MRS. MARY ELSBERG.
PROF. FRANKLIN W. HOOPER.
DR. C. L. LINDLEY.
MR. MORRIS H. BROWN.

Mme. ALICE D. LE PLONGEON read a paper on

YUCATAN, ITS ANCIENT TEMPLES AND PALACES.

(Extract.)

The peninsula of Yucatan was once the seat of a great and powerful empire, whose dominion extended over the whole of Central America, and whose people, a few thousand years ago, were as highly civilized as were the Egyptians in their most palmy days. The ruined temples and palaces of the Mayas still loom amid the towering forests that cover the greater part of the land; and from time to time strangers are attracted to those shores by a desire to see those most ancient structures, whose stone walls could tell many a tale were they but gifted with speech. But are they altogether dumb ? Ah, no ! for graved upon their weather-beaten surfaces there are records and ornaments full of meaning that have for centuries awaited interpretation. Yet each one that gazed said that those hieroglyphics must forever continue a mystery.

This can no longer be affirmed. A key to these strange signs has been found, and it only remains for those who would learn the ancient history of this continent to use it.

The ancient city that is most frequently visited is Uxmal.[1] It is but one day's journey from Merida, the capital, and not much exposed to the hostile Indians. The various structures are not far apart, and were probably at one time the centre of a large city. The "House of the Governor" is a magnificent edifice, built on the uppermost of three very extensive terraces that must have taken almost as long to pile up as any one of the great Egyptian pyramids—not that they are so high, but for the extensive area which they cover.

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[1] Pronounced Ooshmal.

Beneath the surface of the second terrace there are several very curious cisterns, that have their mouths covered with a circular stone, the top of which is on a level with the surface. The cisterns are shaped like a bell, or large round bottle with a flat bottom. They are 13 feet deep, and 19½ feet in their widest diameter, the neck being but 18 inches wide and nearly 3 feet deep. They are lined with square hewn stones fitted close together, and thickly coated with fine plaster, making them perfectly watertight. We have found remains of stone canals about 8 inches wide, by which the rain-water was undoubtedly conducted to the large number of cisterns existing throughout the city, both in terraces and highways. It is quite likely that the inhabitants depended entirely upon rain-water, for they even constructed artificial lakes that served as reservoirs; these yet exist, and are lined with hewn stones.

The "Governor's House," that crowns the uppermost terrace, although 318 feet long, appears quite small in comparison with the terraces. It is divided into as many rooms as the civic year of the Mayas had months, that is twenty. The two largest rooms are 60 feet long, and all the ceilings form triangular arches, the apex of the arch being about 22 feet above the floor. The west side of the building is a dead wall 8 feet thick, the others being 3 feet. They are faced with square hewn stones, fitted so closely together that nothing whatever can be introduced between them. The latter were covered with fine plaster, as we see by fragments here and there, though the greater part is crumbled to dust and mingled with the broken concrete floor. Outside, the cornice above the doorways supports a magnificent entablature, that at first sight seems to be composed of incomprehensible designs, but they in fact represent the face of the mastodon, the name of that American elephant, the names of the founders of the city, with statues of those individuals, and an account of what they did. The grecque ornament that in ancient Egypt indicated splendor is a prominent feature in that splendid façade. There are some much-mutilated statues with a background of plumes surrounding them as a canopy; others have disappeared entirely, leaving only the pedestal on which they once rested. Over the centre doorway we find the broken statue of Prince Aac. From his waist three heads were suspended, and beneath his feet there were three flayed bodies. He was surrounded by bas-relief inscriptions telling of his great exploits, and how he had vanquished or killed all who opposed his wishes, slaying even those of his own family, and boasting of his infamy by having heads made to the likeness of his sister and brothers, suspended from the waist of his own statue and their flayed bodies beneath his feet.

From the Governor's house we look northward upon a palace of 102 rooms, and having descended from the great terraces, after a five minutes' walk, find ourselves in an archway that leads to an interior court. In the upper part of the arch there are traces of red, blue, and yellow paint, as well as various red hands. Similar imprints are seen in several buildings, because it was customary for those who used or owned the edifice, to dip their hands in red liquid and press the palm against the wall to invoke a divine blessing for the house and inmates, and also to denote ownership. The hands were evidently pressed on the walls even before the plastering was done, because in places where the the stucco has fallen, we occasionally see such perfect impressions that the furrows of the palm of the hand are plainly discernible. The red hands are of more interest than would at first sight appear, for by means of them we are enabled to know the stature of those people.

Whenever the natives are questioned about the old houses, they say, "The pygmies built them," but the red hands do not verify this. On the contrary, some of the hands are very large, one that we found being thirty centimetres, or about twelve inches long, though the greater number were of medium size. At the same time it must be confessed that the natives probably had well-founded traditions that cause them to talk of pygmies; for on the east coast of the peninsula and in adjacent islands we found ruined cities where all the houses—built of white limestone—are so small that only pygmies could have lived in them, the doorways being but three feet high and one and a half wide, while every part of the structure is proportionately small.

The palace of 102 rooms forms a quadrangle open at all the angles. All the façades are elaborately ornamented, and each is quite different from the others. That on the west side of the court is the most destroyed, though it was undoubtedly the most interesting. Two large feathered serpents extended from one end of the façade to the other, along the upper and lower edge of the entablature. At regular intervals the snakes are entwined, and intersect the other designs, forming, as it were, panels. At each end of the façade there was a serpent head, the tail of the other drooping above it. They have seven rattles, and just above them an ornament like a peculiar urn with a long plume dependent from it. The heads were crowned, and in the distended jaws of the one yet in place, there is a bat's head, recognizable by the little trunk-like prominence seen on the snout of the species of bat found in Yucatan.

The bat's mouth is open, and in it is the face of a woman, wife of King Can who built the palace. Her name was Zoo, which means bat. Among the débris we found the snake-head that had fallen from the other end, and in the jaws was the face of a man, probably intended to represent King Can himself.

These snakes were not meant to portray the winged serpent that among the Mayas was regarded as an emblem of the spirit of the universe. The latter was not represented with rattles, but had a dart at the end of the tail, and the body was not covered with feathers, but had wings, and here and there something like fins which were intended to represent mountain peaks, for in the earliest times the serpent was symbolical of the country of the Mayas. As a symbol of the country, and afterwards of the earth, the serpent's belly was painted yellow, indicating subterranean forces that upheave the lands ; the back was green to denote the sea and the vegetation of the earth ; the top of the head being blue like the heavens.

The entwined rattlesnakes, completely covered with feathers, and without wings, but having crowns on their heads, simply show the alliance of King Can (snake) and Zoo Chi. The Maya of king-snake is Ahau Can, which is also the name of the rattlesnake. The reason why the snakes are covered with feathers is that the royal consorts, as well as the priests and nobles, on all state occasions, wore robes made of gorgeous feathers which the exquisite birds of that sunny clime afforded them.

Only a few yards east of the palace there is a lofty pyramid crowned with a building that is commonly called "The house of the Diviner." The ascent to it was by stairs on the east and west sides of the pyramid, very steep, and each step only just wide enough for the feet, though the staircase itself, on the east side, is 14 metres wide, or 45 feet, being composed of 96 steps. Some people will not attempt to ascend the stairs until a rope is secured at the top for them to steady themselves by, if necessary. Others go up bravely, and are then filled with dread at the idea of descending. But the Indians run up and down with the greatest confidence, even loaded ; and we learned to do the same thing, having, at one time, to visit the building every day, and generally with our hands full of instruments and other things needed for the work. The pyramid was once incased with hewn and sculptured stones, but now it is covered with bushes. The stairs on the west side are quite destroyed; they led to a platform two metres (6½ feet) wide on which stands a building that was once a sanctuary. Its only entrance faces the stairs, and is 13 feet high. The interior is divided into two rooms. From base to top the exterior is covered with sculptures. All round the cornice there are cross-bones, and the upper half of human skeletons with uplifted arms. Immediately over the entrance there are two large projecting stones above which may be seen two figures representing naked men on their hands and knees, back to back. They occupy the place of a mastodon trunk which was removed from the enormous face over the doorway to make room for them and an inscription that tells of the downfall of the dynasty of the CANS, the change having been made by the Nahualt invaders. Dr. Le Plongeon has already published his interpretation of the inscription, which reads as follows: *The Cans now fallen are crouching like dogs, without strength; the land of Aak, Oxmal (Uxmal) is securely fettered.*

On the right-hand side of the sanctuary some stairs led to another structure that was on the summit of the pyramid. It does not appear very large and yet in reality it is as long as the pyramid is high, that is to say 22 metres. There are three rooms, but they do not communicate with each other, those at the end opening to the east, and the middle one to the west. This building in ages gone by was a temple where scientific men met together, and initiated privileged scholars into certain rites and mysteries, as in the temples of Egypt. Signs used in masonic lodges to-day even yet exist in that building.

Yucatan has an area of about 13,000 square miles, and in different parts of the territory there are at least forty ancient cities. One of the most remarkable is that called Chichen-Itza, a place so exposed to the hostile Indians that, when we first declared our intention of making a stay there, our acquaintances in that country declared that we would never return alive, and when they were convinced that we could not be dissuaded, Gen. Palomino, then commander-in-chief of the military forces, ordered Col. Diaz, who was at the head of the troops in that district, to provide us with an escort of 100 men. Wishing to see the ruins, the Colonel himself accompanied us, and the morning when we started, as we passed through the streets, the people came out of their houses to wish us a safe return, because they regarded our expedition as most perilous.

The first building that comes into view on approaching the old city of Chichen is a grand castle on the summit of a lofty pyramid. In that castle there are many sculptured pillars, and among the figures represented there are several men with long beards, the faces all in profile. One was sufficiently like Dr. Le Plongeon for the Indians to affirm that it was himself when he had lived in that spot in ages gone by. As those natives believe in re-incarnation, we were not surprised to hear them speak thus, and did not think it worth while to contradict them, for such a belief would cause them to obey us more readily, as indeed it effectively did.

The largest structure at Chichen is a great palace that is about three-quarters of a mile distant from the castle. It is three stories high, the stairs being outside, and the rooms are not one over another, but on solid blocks of masonry, the roofs of the lower rooms having been used as hanging gardens. The grand entrance that leads into the rooms on the ground floor is remarkably interesting, for over the doorway is a tableau which is nothing less than a representation of the mythical account of the creation of the world, corresponding exactly to what we read in the first chapter of the Manava Dharma Sastra, a book compiled from the works of the Brahmins about 1300 years B.C. In that chapter we read: "The Supreme Being having resolved to make the divers creatures come forth from his own corporeal substance first produced the waters" (a representation of rippling water forms the rim of the tableau) "and in them deposited a productive seed. This germ became an egg" (as we see over the door in the midst or centre of the water) "brilliant as gold, resplendent as a star with a thousand rays" (so the egg in the tableau is surrounded by rays). "And in the egg was reproduced the Supreme Being under the form of Brahma, the ancestor of all beings." The egg in the tableau likewise has a figure in it; and on each side of the egg there is an inscription that is written with Egyptian letters in the Maya language. According to Champollion le jeune this character  corresponds to the Latin *H*, and this Egyptian sign  or  to the Latin *M*, and in plate XII. of his text-book we find these very signs translated by him *engendered—manifested*. In the tableau, for the symmetry of the drawing, the word is four times repeated, and means *Mehen*, the broken line representing the water, having the phonetic value of *N*, in Mayax (ancient Yucatan) as in Egypt; and Mehen means in the Maya language, the *son*, the *engendered*.

But that is not all. Eusebius tells us that the Egyptians represented the Creator of the world, whom they called Kneph, under a human form with the flesh painted blue, a belt surrounding his waist, holding a sceptre in his hand, his head being adorned with a royal head-dress ornamented with a plume. Strange to say, the figure within the egg yet preserves traces of blue paint, and blue was emblematic of holiness among the Mayas, as it seems to have been in Egypt and elsewhere; the Indian God Vishnu was painted blue. The figure in the egg has likewise a belt, a badge in the hand, and the head adorned with a large plume of feathers. Eusebius also informs us that Kneph, the Creator, was represented emblematically by the Egyptians as a serpent, and called the good genius (*Αγαθοδαιμων*). *Kneph* is equivalent to *Ka-neph*, and no doubt also to *Can-neh*, which is a Maya word meaning dragon, serpent.

The background of the tableau, within the egg, behind the figure, represents the scales of the serpent's skin. Moreover, the lines representing water, terminate above the egg, in serpent heads—*Can-neh.*

A very interesting structure at Chichen are two parallel walls, 270 feet long, nearly 20 feet thick, and 42 feet high, that once served as tennis court or gymnasium. The walls run north and south, and on the south end of the east wall there is a monument that was built by a certain queen named Moo, to the memory of her husband, as we learn from the decorations of the outer wall. Although there is nothing in them that could be called an inscription, Dr. Le Plongeon discovered that they had a written meaning, which, interpreted in English, is as follows: MOO FERVENTLY INVOKES COH, THE EMINENT WARRIOR.

Within the chamber there are most interesting mural paintings, giving a pictorial account of the life of that same warrior. Unhappily the greater portion of the precious paintings were effaced. Those that were yet distinct enough, with all their colors, for us to make a copy of them may be regarded as treasures, for they are, as far as we know, the only vestiges now existing of ancient American fresco paintings. They show religious ceremonies, domestic scenes, and battles. The colors are red, yellow, white, green, and blue, and are laid on in flat tints, the outlines being dark brown. The figures vary in height between six and nine inches, and show a far more skilful hand than those portrayed in the paintings found in the tombs of Egypt. The copies in our possession are fac-similes of the originals, and consist of 24 tableaux, that would be a unique acquisition to any museum or private collection of antiquities.

Guided by those mural paintings and certain signs that we had interpreted, we were led to search for the burial-place of the individual to whose memory such a beautiful monument had been erected, and we were not disappointed, for we found the mausoleum, but it was in a ruinous condition. It had been a quadrangular mound about 13 feet high, faced with sculptured stones. At each corner there were four stone slabs with a macaw (*Ara militaris*) carved in two of them, and a leopard on the other two. All these figures had a heart in the fore paw or claw. Each leopard is represented with three holes in the back; and a few steps from the mound we discovered a leopard carved in the round, in a reclining position, also with three holes in its back, but the head was wanting. A search among the débris brought to light a human head that had evidently belonged to the leopard, as when applied to the neck it fitted exactly. This sphinx, taken in connection with other things, made it plain to us that we had found the mausoleum of Prince Coh, or Chaacmol, which is the Maya word for leopard, who came to his death at the hands of his brother from wounds treacherously inflicted in his back.

We found the interior of the mausoleum consisted of large, loose stones piled one above another very carefully, and among them, after many days' work, we found, 20 feet below the surface, a large statue and two urns containing the cremated remains of the prince whom the statue had been made to represent. With the remains we found a talisman of jadeite, some beads, and around the base of the statue several very beautiful arrow heads of pure white chalcedony; and others of a semi-transparent green stone.

Our Indian laborers were afraid to put their hands on anything, believing that if they touched what had belonged to the ancients they would inevitably be overtaken by death before one year elapsed. The result of this fear was that more than once they revolted, and gave us some trouble, especially when, after almost insurmountable difficulties, we had the statue, which weighed 300 pounds, in a position to be drawn from its long resting-place. Having no hemp at hand—in that country where so much of it grows—we had caused the men to make ropes from the pliant bark of a certain tree; and the capstan, by which the great statue was to be pulled to the surface up an inclined plane, was made of trunks of trees and a stone ring that we had been happy enough to find near the spot. To keep the loose stones in the sides of the excavation from falling on the statue, we had constructed a palisade of saplings around, and when our men saw that it was really to be taken from its tomb, they made an attempt to cut the withes that secured the palisade; and, finding that their own efforts to prevent the removal of the great effigy were unavailing, they hoped that some unseen power would come into play, in fact they were almost confident of it, for when ordered to work the capstan they said: "The king tiger cannot be moved, he is enchanted." And when the rope stretched and snapped without having moved the ponderous image one inch, they shouted with exultation; but Dr. Le Plongeon mended the rope, and at the end of fifteen minutes the statue had been successfully brought above ground, and the Indians stared in bewilderment. Without a nail, screw, or other tool than a large *machete,* we made a small cart for the statue, and dragged it to the nearest village, opening and levelling the road as we advanced foot by foot.

I regret to say that, after we had succeeded in getting it into the territory guarded by Mexican troops, the statue was seized by the authorities and taken—on board the Mexican gunboat "Libertad"—to Mexico, where it is now in the museum of the capital, though that government has never given us anything for our time, labor, and expenses, and has declined to make amends in any way; and we have as yet failed to obtain any redress through our own, the American government.

During another stay at Chichen, we opened a larger mausoleum that had been built over the remains of a wise man and soothsayer. In the urn that contained the remains we found a large square talisman of jade stone, having a human face carved on it, surrounded by signs and characters that mean CAY CANCHI (a name), THE HIGH-PRIEST OF THE SUN. As a hole was pierced through the stone, we may presume that it was worn by the priest.

Besides the urn and a statue, we found in that mausoleum 182 conoidal pillars, some painted blue, others red, averaging from 2½ feet to 4 feet in height. Also 12 serpent heads, exquisitely sculptured and painted in bright colors. These and the pillars were probably objects from some temple destroyed in very remote times.

The 12 serpent heads recall to mind the 12 gods that, according to Herodotus, were said to have ruled over Egypt before the time of their first human king, Menes; and would seem to correspond to 12 heads that we find in the same edifice where we see the Creation tableau, already described. The decorations on the outside of that building are chiefly representations of the face of the mastodon, and between the eyes of 12 of those faces there is a human face surrounded by an aureola or halo, life-size, intended, no doubt, for portraits of ancient rulers.

Although we have made remarkable and gratifying discoveries, they are nothing compared to what we might yet do under favorable circumstances. We wish to continue the work, but cannot unless aided. Of the grand buildings in Chichen and Uxmal, we have made perfect moulds, photographs, and plans, at a large outlay of time, labor, and capital, for during twelve years we have spent $50,000 on the work.

The moulds that we made of the antique sculptures are stored in New York City. With them, fac-similes of the ancient temples and palaces could be made, so that, although each year that passes leaves those structures more destroyed, the ancient works of art will not be lost, since from our moulds they can be reproduced in plaster or terra-cotta and studied without the inconvenience of dwelling in dense forests where leopards chase the agile deer, and venomous reptiles and insects lurk on every side.

If, on the other hand, some scholars should prefer to study *in situ*, why not establish in Yucatan, amidst the stupendous remains of a great and surprising civilization, a school for their study, and for that of the Maya language, one of the most ancient forms of speech, coeval with, if not anterior to the Sanscrit? Schools have been established by Americans, the same who have asserted that there is nothing worth studying in the antiquities of America, in Athens for the study of Greek archæology; and in Cairo for the deciphering of the inscriptions carved on the temples and obelisks of Egypt.

It is surprising that Americans should despise and neglect the ancient monuments of their own land, while Europeans recognize their importance and endeavor to unveil the past history of this continent. The *Société des Americanistes* in Paris, send people from that capital to procure ancient American sculptures for the Trocadero Museum.

Surely it is time that we should know more about the ancient history of the continent on which we live. That history is not altogether lost, as has been generally affirmed. There are interesting inscriptions that only await interpretation. We have some in this city. Our labor of twelve years has not been in vain, for we have found a key that will unlock the door of that chamber of mysteries, the hitherto incomprehensible American hieroglyphics. After long and patient study of mural inscriptions Dr. Le Plongeon has discovered what were the various signs or letters of the ancient Maya hieratic alphabet, and how similar many of them are to the Egyptian hieratic alphabet.

March 8, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

A large audience assembled in the east lecture room of the Library Building, Columbia College.

The fourth lecture of the Popular Lecture Course was delivered by PROF. GEORGE F. BARKER.

Subject: RADIANT MATTER.

(Experimentally illustrated.)

March 15, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Seventy persons present.

A paper by C. HART MERRIAM,

DESCRIPTION OF A NEW SPECIES OF APLODONTIA FROM CALIFORNIA (*Aplodontia major*) was read by title.

(Published in the Annals, Vol. III., No. 10.)

PROF. H. CARRINGTON BOLTON read a paper on

RECENT PROGRESS IN CHEMISTRY.

(1.) To many intelligent and cultivated persons not specifically instructed in chemistry, this word recalls confused memories of colored liquids, glistening crystals, dazzling flames, suffocating fumes, intolerable odors, startling explosions, and a chaos of mystifying experiments, the interest in which is proportional to the danger supposed to attend their exhibition. Further reminiscences are of many singular objects in wood, metal, glass, and earthenware, of flasks and funnels, of retorts and condensers, furnaces and crucibles, together with bottles innumerable filled with solids, liquids, and gases, the whole paraphernalia connected by glass tubes of eccentric curves, and displayed in inextricable confusion and meaningless array. Behind this chaos arise vague memories of one discoursing learnedly in a polysyllabic jargon, and attempting to explain the unusual phenomena by the aid of abstruse hypotheses, but utterly failing to remove the sensations of awe and of mystery bordering on the supernatural which overwhelm the hearer—impressions that have clung to chemistry ever since its entanglement with the superstitions of alchemy, astrology, and the "black art."

Persons who undertake to gain through chemical literature a knowledge of what chemists are doing in and for the world, encounter a discouraging nomenclature which repells them by its apparent intricacy and its polysyllabic character. Their opinion of the terminology of an exact science is not enhanced when they learn that "black lead" contains no lead, "copperas" contains no copper, "mosaic gold" no gold, and "German silver" no silver; that "carbolic acid" is not an acid, "oil of vitriol" is not an oil, that olive oil is a "salt," but "rock oil" is neither an oil nor a salt; that some sugars and some kinds of wax are alcohols; that "cream of tartar" has nothing in common with cream, "milk of lime," with milk, "butter of antimony" with butter, "sugar of lead" with sugar, nor "liver of sulphur" with the animal organ from which it was named.

Readers of chemical writings sometimes fail to appreciate the advantages of styling borax, "di-meta-borate of sodium," or of calling common alcohol "methyl-carbinol," and they ignore the euphony in such words as pentamethyldiamidothiodiphenylamindiiodomethylate (a substance begotten and baptized by Dr. Albert Maasen).

Those whose chemical education consisted in attendance on a course of lectures illustrated by experiments performed in their presence, interspersed with occasional recitations from a prosaic text-book which taxed the memory in true Chinese fashion, may be pardoned for retaining very hazy impressions of the true character of the science. On the other hand, many thinking and reading persons recognize the magnitude of the scope and operations of chemistry, and have some appreciation of its benefits to mankind.

(2.) The fields of chemistry explored by zealous investigators are prodigious in extent and diversity; in its various sections, analytical, agricultural, pharmaceutical, physiological, and technological, it yields fruit of infinite value to the human race, and, co-operating with other sciences, produces results which promote civilization in the highest degree. So rapidly are new methods of cultivation applied to these fields, so numerous and active are the workmen engaged in tilling them that the harvest is too abundant for mental storage, and those who survey the operations at a distance are quite unable to apprehend the products. This inability to follow the advances made by chemical science is felt not alone by those whose imperfect and non-technical training has illy fitted them for the task; even the specialist stands aghast at the prospect, and abandoning attempts to apprehend the progress made in all departments, confines his reading and research to a limited number.

The twelve principal Chemical Societies of the world have an aggregate membership of over eight thousand;[1] nearly all of these members are actively contributing to the advancement of chemical science, publishing their results for the most part in periodicals especially devoted to the subject. Excluding Transactions of Societies, and Journals of Physics and Pharmacy, these chemical periodicals issue annually about twenty thousand pages. Bearing these statistics in mind, are we not justified in feeling appalled at the idea of presenting within the compass of an evening's address a review of Recent Progress in Chemistry? Any attempt to do more than glance at a few salient points is obviously out of the question. "Recent" time will of necessity be a somewhat variable quantity, its limits being determined by expediency. We shall also endeavor to bear in mind the fact that we address an audience not exclusively composed of professional chemists.

(3.) Much interest is commonly attached to announcements of new forms of matter; an interest out of proportion perhaps to the real value of the discoveries. During the last nine years chemists have not failed to sustain this interest, for they have proclaimed no less than thirty-one new elementary bodies. The ambition of these chemists, however, has been greater than their accuracy, for of these thirty-one bantlings but five or six have survived the scrutiny of the doctors, two or three are now in precarious health, and the remainder have been buried or cremated without ceremonies. Of the youthful survivors comparatively little is known; their character is being severely tested, and their future destiny and utility is yet uncertain. The extreme rarity of the minerals in which the new elements have been detected, the excessively small percentages of the new ingredients, the extraordinary difficulties attending their separation from known substances combine to render the investigations laborious, protracted, and costly. From twenty-four hundred kilogrammes of zinc blende, Lecoq de Boisbaudran, the discoverer of gallium, extracted sixty-two grammes of the precious metal; compared with this element, therefore, gold is both abundant and cheap. Ytterbium, Scandium, Samarium, Thulium, and the rest will long remain mere chemical curiosities known to but few; probably the most sanguine will not claim for them a future place among substances of economic value.[2]

(4.) But of far greater importance than the elements themselves is the marvellous delicacy of the means used in detecting and isolating them. When Bunsen and Kirchhof presented to scientists the instrument which combines the penetration of a telescope with the power of a microscope magnified an hundred-fold, they were enabled to disclose nature's most hidden secrets. The new elements have been traced to their hiding-places, their differences established, and their subsequent purity demonstrated, chiefly by their emission and absorption spectra. Three years ago, William Crookes, who had already discovered thallium by the aid of the spectroscope, announced a novel and remarkable extension of the power of this instrument. Crookes[3] found that many substances, when struck by the molecular discharge from the negative pole in a highly rarefied atmosphere, emit phosphorescent light of varied intensity. Having observed under these conditions a bright citron-colored band or line, he pursued the substance producing it, and, after a laborious search, found that it belonged to yttrium. Subsequent studies showed this modification of spectrum analysis to exceed in delicacy all known tests for the rarer earths; yttrium can be detected when present in one millionth part. Within a twelvemonth, Crookes has made known the application of radiant matter spectroscopy to samarium; the delicacy of this test surpasses that for yttrium, and the anomalous behavior of the mixed earths yields phenomena "without precedent."[4]

About the same date as the later communication by Crookes, Lecoq de Boisbaudran[5] published a method of obtaining what he terms "reversion spectra," which is practically the same in effect as that of Crookes. The French savant finds indications of two new elements in certain brilliant lines, but Crookes distinctly warns us that "inferences drawn from spectrum analysis *per se* are liable to grave doubt," and "chemistry after all must be the court of final appeal." Crookes' reflections on the sufficiency of spectrum observations as criteria of the elementary character of bodies are justified by the experience of many, notably of Sorby, whose pseudo-jargonium is well remembered. This difficulty arises especially with absorption spectra, and neglect of the warning given by Sorby has led several chemists into fruitless researches.

(5.) When Dalton, the Manchester schoolmaster, added to the atomic theory of the Greeks the laws of definite and of multiple proportions, he transformed an "interesting intellectual plaything" into an exact scientific theory capable of experimental demonstration. The importance of ascertaining the atomic weights of the elements with the utmost accuracy has stimulated chemists to apply to the problem their best endeavors; and as the methods of analysis become more refined the determinations are again and again repeated, every ascertainable and imaginable source of error being carefully eliminated. Beside the experimental repetitions, the figures obtained by various observers have recently been submitted to careful re-calculations by Clarke,[6] in this country, and soon after by Lothar Meyer and Seubert,[7] in Germany. Their labors give chemists the latest and most reliable constants.

The prevailing, though partly unacknowledged, adherence to Prout's hypothesis, leading chemists to prefer whole numbers (or at least even fractions) for the atomic weights, is liable to result in confusion and perplexity. Stas demonstrated that the atomic weight of oxygen is not quite sixteen times as great as that of hydrogen, but that when $H=1$, $O=15.96$. The tendency to disregard this difference of $\frac{1}{400}$ is unfortunate, since important errors in calculations, based on organic analyses, might result therefrom. Lothar Meyer and Seubert show that in the analysis of compounds of carbon and hydrogen, the error introduced by making $O=16$ is greater than the errors of observation, and in the analysis of a body belonging to a homologous series doubts might arise as to the identity of the body under examination.[8] Of course, the formula of a body is not determined by analytical data alone; still, this liability to errors marks forcibly the desirability of greater uniformity in the standard of values for the atomic weights.

Contrasting strongly with belief in the absolute character of the weights of atoms is the suggestion of Boutlerow and others that the law of definite proportions is subject to variations. In 1880, Schützenberger observed a curious anomaly in analyzing some hydrocarbons. He found that the sum of the carbon and hydrogen was 101 for 100 parts of material, the result under other conditions being normal. Boutlerow called attention to this, and expressed the opinion that the chemical value of a constant weight (or rather mass) of an element may vary, and that the so-called atomic weight of an element may be simply the carrier of a certain amount of chemical energy which is variable within narrow limits. At a meeting of the Chemical Society of Paris, where Professor Wurtz presented a summary of the views of Boutlerow, an interesting discussion followed; this subsequently drew from Prof. Josiah P. Cooke, of Harvard, a communication in which he shows that he had expressed similar views more than twenty-five years before. As early as 1855, he had questioned the absolute character of the law of definite proportions, and had suggested that the variability was occasioned by the very weak affinity between elements manifesting a fluctuating composition. These speculations are interesting to theorists, but do not seriously impugn the status of chemical philosophy.[9]

(6.) For many years, chemists have dimly perceived the probable correlation of the properties of the elementary bodies and their atomic weights. Dumas pointed this out for certain marked groups, Newlands[10] emphasized it; but it remained for a Russian chemist, Mendelejeff,[11] to establish, in 1869, a law of great importance. Mendelejeff showed that if the elements are grouped in the order of their atomic weights, it will be found that nearly the same properties recur periodically throughout the entire series. This so-called Periodic Law is more concisely stated thus: The properties of the elements are periodic functions of their atomic weights. The accuracy of the deductions based on this law is strikingly shown by the fact that Mendelejeff, finding an unfilled blank in the periodic system, boldly announced the the general and special properties of the element awaiting discovery; six years later, Lecoq de Boisbaudran discovered gallium, an element which proved to have properties almost identical with those of the hypothetical *eka-aluminium* described by Mendelejeff. And in 1879, the accuracy of Mendelejeff's prophecy was further confirmed by Nilson's discovery of scandium,[12] the counterpart of the hypothetical *ekabor*. *Eka-silicon*, though yet to be discovered, may almost be regarded as a known element, so fully have its properties been predicted.[13]

The correlation between atomic weights and physical properties is being extended, and now embraces the fusibility, boiling-points, general affinities, color, occurrence in nature, physiological functions, and many other factors.[14] Dr. Carnelley,[15] who has been active in developing this subject, at the Aberdeen meeting of the British Association, proposed a "reasonable explanation" of the periodic law;[16] he regards the elements as compounds of carbon and æther, analogous to the hydrocarbon radicals, and suggests that all known bodies are made up of three primary elements, carbon, hydrogen, and æther—an assumption which cannot be disproved.

In recent years the periodic system has exerted noteworthy influence on the classification of the elements and their compounds. It is of positive utility in determining unsettled questions concerning new and rare elements, and is destined to maintain a lasting hold on chemical philosophy.

(7.) The question whether the known elements are truly primary forms of matter has long occupied the thoughts of chemists, and the problem constantly acquires new features. The influence of high temperatures on the spectra of the metals has been a fruitful source of speculations. In 1878, the English astronomer and physicist Lockyer[17] announced the discovery of the resolution of the elements into one primary matter; but when Lockyer's paper was read before the Royal Society his discovery proved to be little more than a hypothesis, and that not a new one, he having been virtually anticipated by Professor F. W. Clarke, of Washington.[18] However, Lockyer's hypothesis was based in part upon experimental evidence. After eliminating coincidences in the lines of the spectra of various metals, due to impurities, so large a number of identical lines remained that he advocated the assumption that these are produced by a primary matter common to the so-called elements. He pointed out that in the hottest stars, Sirius for example, hydrogen only is present, and argued that at extremely high temperatures the so-called elements are broken up into hydrogen, the ultimate matter of the universe. Lockyer's announcement excited, temporarily, a lively interest, but his views are not regarded as supported by sufficient evidence.

More recently, the doctrine of "structure" has been borrowed from organic chemistry, and applied to the elementary bodies; the relations existing between the elements is so similar in many respects to the relations between the hydrocarbons in a homologous series, that the elements have been regarded as compounds of carbon with an unknown primary form of matter. Experimental evidence is lacking, but the hypothesis takes a plausible form.

Dr. Carnelley, as elsewhere stated, suggests that elements are compounds of hydrogen, with the all-pervading æther of the physicist; but we venture to remark that attempts to explain the nature of elements by assuming them to be compounds of hydrogen with a substance whose very existence is itself assumed, is, perhaps, an intellectual amusement, but not likely to advance the exact sciences.

During the past year an Austrian chemist has announced the decomposition of didymium by purely chemical means, and the discovery of praseodymium and neodymium as its constituent elements.[19] An English chemist claims to have evidence of the existence of an allotropic form of nitrogen.[20] Both these statements await confirmation.

(8.) The views of chemists concerning the nature of affinity and chemical action are undergoing modifications destined to wield an important influence on the science in the near future. The notion has prevailed, though not distinctly formulated, that the chemical attraction exerted between unlike atoms is a superior sort of cohesion, powerful and absolute; and this force was thought to operate between two elementary bodies directly, without the intervention of a third kind of matter. That this so-called affinity is radically affected by physical state, by heat, and by electricity has been admitted, but the conviction is growing in the minds of chemists that many circumstances influencing the union and separation of elements have been overlooked; they are beginning to believe that chemical action does not take place between *two* substances, and that the presence of a third body is important, if not, indeed, indispensable. Many years ago the word catalytic was coined to describe certain isolated phenomena little understood. These phenomena are familiar to chemists, and the number is increasing; the word catalytic is, however, in disfavor, and the term contact-actions is now current. The well-known influence of finely-divided and heated platinum in effecting the union of sulphur dioxide and oxygen, and the action of metallic silver in decomposing ozone without itself undergoing any change are examples. In these and similar changes one of the substances indispensable to the reaction remains unchanged, and its rôle cannot be expressed in equations.

Dulong and Thénard,[21] more than sixty years ago, showed that the temperature of ignition of a mixture of hydrogen and oxygen is lowered to a remarkable degree by the presence of solid bodies of varied nature. Within a few months, Menschutkin and Konowalow[22] have made a study of the influence of asbestus, glass, and other bodies on the decomposition-temperature of many organic compounds.

There is another class of reactions in which one body acts upon another only through the aid of a third, which maintains its identity at the close of the reaction, yet is known to be decomposed and recomposed successively throughout the operation. By heating a relatively small quantity of cobaltous chloride with bleaching powder, the latter is wholly decomposed, yielding calcium chloride, water, and oxygen, yet at the close of the reaction the cobaltous oxide is found unaltered. It has been shown that it is successively decomposed and recomposed during the operation. In their investigation on "Simultaneous Oxidation and Reduction by means of Hydrocyanic Acid," Profs. Michael and Palmer[23] consider it probable that many of the most important reactions of animal and vegetable life are due to the intercession of substances which undergo change during the reactions, and in the end return to their original form. They suggest also that some of these reactions seem to be dependent on substances capable of decomposing water into its elements, or into hydrogen and hydroxyl; and when the chemist can command a reagent possessing that property at a low temperature, their imitation in the laboratory may follow its discovery.

(9.) That chemically pure zinc is not soluble in dilute sulphuric acid has been known since Faraday's day; that sodium does not combine with perfectly dry chlorine, even if the metal be heated to its fusing-point, was shown by Wanklyn[24] in 1869; more recently, Mr. Cowper has found that dry chlorine does not attack Dutch metal; six years ago, Mr. H. B. Dixon[25] demonstrated before the British Association that a well-dried mixture of carbon monoxide and oxygen can be subjected to the electric spark without exploding. In March, 1885, Mr. H. B. Baker[26] communicated to the London Chemical Society results of his experiments on the influence of moisture in the combustion of carbon and of phosphorus in oxygen, his conclusions being that the combustion of dry charcoal in dry oxygen is incomplete and slower than in ordinary moist oxygen. In the discussion which followed Mr. Baker's paper, Dr. Armstrong pointed out the importance of these new facts in defining more accurately conceptions of chemical action, and suggested that chemical action is "reversed electrolysis." In his address as president of the chemical section of the British Association for the Advancement of Science (Sept. 10, 1885), Dr. Armstrong further discussed this subject, and stated that the idea conveyed by the expression "reversed electrolysis" is found in the writings of Faraday, neglect of whose teachings retards the progress of chemistry.[27]

The influence of low and of high temperatures in retarding and facilitating chemical changes is fundamental, but some phenomena not generally known may be appropriately mentioned. Victor Meyer and Langer[28] have shown that whereas chlorine violently attacks platinum at low temperatures, it is without action upon the metal between 300° and 1,300°, and begins to act upon the platinum above the latter temperature, the action becoming violent at 1,600° to 1,700° C.

Liquefied ammonia at −65° does not combine with sulphuric acid, but swims on its surface without mixing with it.[28A] Donny and Mareska[29] long ago showed that sodium retains its luster in liquid chlorine at −80°, and quite recently Prof. Dewar demonstrated that liquid oxygen is without action on sodium, potassium, phosphorus, solid sulphuretted hydrogen, and solid hydriodic acid. He further experimented with other substances normally active, and found their affinity at very low temperatures destroyed.[30]

(10.) Attempts have been made to solve the problem of a general theory of chemical action by means of the data of electrolysis and of thermo-chemistry. The subject is further complicated by the phenomena of induction, of predisposing affinity, and of influence of mass. Lastly, but not least, the term affinity is itself used in a vague way, expressing different ideas at different times and by different authors, some writers doubting the expediency of employing the word at all, and favoring the more general expression chemical action. The true nature of chemical action has yet to be satisfactorily explained ; only the most general conclusions are fairly deducible from the data in hand; namely : "that each chemical substance which forms a member of any changing system exerts a specific action on the course of the changes which that system undergoes."[31]

Chemists are beginning to realize that many phenomena regarded as simple in character are in reality quite complex. A single example must suffice. From Lavoisier's day until a few years ago the combustion of carbon monoxide in the air, or in oxygen was regarded as a very simple phenomenon, satisfactorily explained by the equation :

$$2CO + O_2 = 2CO_2$$

in which two molecules of the gas unite directly with one of oxygen, producing two molecules of carbon dioxide. In 1880, however, Mr. H. B. Dixon[32] demonstrated that this reaction takes place only in the presence of aqueous vapor ; this necessitates an entirely different explanation, as indicated in the following equations :

$$(1.)\ CO + H_2O = CO_2 + H_2$$
$$(2.)\ 2H_2 + O_2 = 2H_2O,$$

that is to say, the carbon monoxide decomposes the water, forming carbon dioxide and setting hydrogen free, which latter gas unites with the free oxygen and thus reconstructs the water.

Within a twelvemonth, however, Traube[33] has shown that carbon monoxide does not decompose water in complete absence of air or oxygen, and hence Dixon's first equation does not represent a fact. Traube also finds that when moist carbon monoxide and oxygen are united by the electric spark, hydrogen peroxide is an invariable product, and he suggests the following explanation of the reaction :

$$(1.)\ CO + 2H_2O + O_2 = CO(OH)_2 + H_2O_2$$
$$(2.)\ CO + H_2O_2 = CO(OH)_2$$
$$(3.)\ 2CO(OH)_2 = 2CO_2 + 2H_2O.$$

These equations may be interpreted as follows: When the electric spark is passed through a mixture of carbon monoxide and oxygen in the presence of aqueous vapor, the first products are true carbonic acid and hydrogen peroxide; the latter at once oxidizes the carbon monoxide, forming a second molecule of carbonic acid; and, finally, the two molecules of carbonic acid are decomposed with the formation of carbon dioxide and water.

If Traube's views be sustained, it is evident that so simple a matter as the combustion of carbon monoxide has long been misunderstood, and disregard of the presence of moisture has led to erroneous conclusions.[34]

Chemists sometimes marvel at the blindness of the alchemists who, though familiar with many chemical processes in which gaseous bodies were evolved, yet disregarded these important factors, and left them for later generations to discover. What will future generations think of us who fail to take into account accessory bodies indispensable to chemical reactions of the most familiar kind.[35]

(11.) The speed of chemical reactions is an important factor in chemical theory, the study of which has but recently begun. Wenzel[36] long ago held that the affinity of metals for a common solvent, such as nitric acid, was inversely as the time necessary to dissolve them, and he experimented with small cylinders, partly protected by wax. Gladstone and Tribe[37] have made attempts to ascertain the rate at which a metallic plate precipitates another metal from a solution, and they announced a definite law. Prof. John W. Langley[38] has since shown that, while their experimental work was correct, their method was faulty, and the results fallacious; he thinks it probable that the true law of chemical action where one metal precipitates another should be thus stated: The time during which one atom replaces another in a compound molecule is constant, and the total rate of chemical action varies directly as the mass of the reacting body in solution.

In his address before the Chemical Section of the American Association for the Advancement of Science, at Philadelphia, Professor Langley[39] discussed the problems of chemical dynamics, and pointed out the rich store of promise in this neglected field. Physics deals with three quantities—space, mass, and time. Chemistry has too long been content with studying the changes of matter in terms of space and mass only, that is to say, in units of atomic weight and atomic volume. The discovery of a time-rate for the attractions due to affinity is destined to throw new light on chemical science, and to render it capable of mathematical treatment.

(12.) A prodigious amount of work has been done in thermo-chemistry, and within a few years, the multitude of isolated observations have been collected, classified, and made available. The importance of this undertaking will be more appreciated in the future than it has been in the immediate past.

In all cases of chemical change, energy in the form of heat is either developed or absorbed, and the amount is as definite in a given reaction as are the weights of the substances concerned; hence, measurement of the quantity of heat set free or absorbed in chemical reactions often enables the chemist to determine the true nature of the change. For example, the exact condition of certain bodies in solution can only be conjectured from certain physical characters, few and ill-defined; but by thermic methods of investigation the bodies formed can be accurately ascertained. This is accomplished by reference to the law of maximum work. "In any reaction, those bodies, the formation of which gives rise to the greatest development of heat, are formed in preference to others." Thus the thermometer alone in skilful hands determines the *à priori* necessity or impossibility of a reaction.[40]

Berthelot,[41] in Paris, and Thomsen,[42] in Copenhagen, have pursued the subject of thermo-chemistry with indefatigable zeal, and their published results form monuments of exhaustive research. "By the labors chiefly of these two men, we now know the thermal values corresponding to many thousands of chemical reactions. We have learned that the energies of a reaction which can be brought about in two methods, either in the dry way or by solution, differ in the two cases; that salts in solution are in a partial state of decomposition; that the attraction of a polybasic acid radical is not the same for the successive portions of base added, and that the behavior of a monobasic acid in solution differs essentially from that of a dibasic or tribasic acid. We also know that the total energy involved in any reaction is largely influenced by the surrounding conditions of temperature, pressure, and volume."[43]

(13.) The interesting border line between chemistry and physics is an increasing subject of research on the part of both the chemist and the physicist. The periodic press chronicles profound studies of the relations between chemical constitution and the phenomena of diffusion, of capillarity, of dialysis, of dissociation, and of the law of isomorphism. We read investigations on the value of the theory of atomicity, and on the nature of nascent action. Researches in the domain of electro-chemistry, especially in connection with the various forms of storage batteries, and in relation to the methods and results of electrolysis, are of such importance as to merit a whole address. The press also records numerous studies in actinometry, of the relations between chemical composition and fluorescence and phosphorescence, as well as of polychroism, and of the results of spectrum observations. Noteworthy are the special applications of optical methods to the determination of molecular structure, viz., the relations between chemical composition and (1) the refractive power; (2), the power of rotating a ray of polarized light; and (3), the absorption spectra of both inorganic and organic bodies.

Bruhl has attempted to show that the relationship between refractive power and molecular structure is dependent on the valencies of atoms, and on the distribution of atomic interactions. Van 't Hoff has developed a hypothesis of a crystallographic character that cannot be discussed in the brief space at our command.[44]

(14.) The meeting of the French Academy of Sciences, held the day before Christmas, 1877, was rendered memorable by the announcement that oxygen gas had been liquefied by two independent experimenters. Previous to that date, hydrogen, oxygen, nitrogen, nitric oxide, marsh gas, and carbon-monoxide had resisted all attempts to liquefy them, whether in the hands of the skilful Faraday, the ingenious Natterer, or the learned Andrews. Physicists and chemists, while admitting the class of so-called permanent gases, had for many years looked forward to their eventual liquefaction, yet the final success came as a surprise. This success was the result of the enterprise and ingenuity of a French iron-master, M. Cailletet, and of a Genevan manufacturer of ice-machines, Raoul Pictet, working independently. In each case, the process consisted in simultaneously exposing the gases to a very high pressure and a very low temperature. Pictet[45] obtained the necessary pressure by generating the oxygen in a wrought-iron vessel strong enough to withstand an enormous strain, and the low temperature was secured by the rapid evaporation of liquid carbonic acid; Cailletet,[46] whose apparatus was marked by extreme simplicity, obtained the great pressure by means of a hydraulic press, and the low temperature by suddenly diminishing the pressure upon the compressed gases. Descriptions of apparatus without diagrams are seldom intelligible; in this place they are superfluous, for we deal with results rather than with methods. Being ignorant of the "critical point" for oxygen, both experimenters employed a much greater pressure than necessary.

Since the initial successes, the problem of liquefying the quondam permanent gases has been successfully attacked by several experimenters, especially by Wroblewski and Olzewski, whose names indicate their nationality.[47] By employing liquid ethylene (which boils *in vacuo* as low as —150° C. [—238° F.]) as a means of cooling the gases under pressure, both oxygen and nitrogen, as well as atmospheric air have been liquefied at very moderate pressures.

Among the interesting results obtained are the following: at —102 C. (—152° F.), chlorine forms orange-colored crystals; at —115° C. (—175° F.), hydrochloric acid is a solid; at —118° C. (—180°F.), arsenetted hydrogen forms white crystals; at —129° C. (—200° F.), ether solidifies; at —130° C. (—202° F.), absolute alcohol solidifies; at —184° C. (—299° F.), oxygen boils; at —191.2° C. (—312° F.), air boils; at —205° C. (—337° F.), air boils *in vacuo*. These extraordinary temperatures were measured by means of an hydrogen thermometer, and by a thermo-pile. The lowest temperature measured (to date) is —225° C. (—373° F.), which was reached by reducing the pressure of solid nitrogen to 4 *mm.* mercury[48] (Olzewski). Further noteworthy results are as follows: nitrogen was obtained in "snow-like crystals of remarkable size;" the liquefaction of air has been so conducted as to obtain two distinct liquids separated by a perfectly visible meniscus (Wroblewski),[49] and, finally, when hydrogen was subjected to between 100 and 200 atmospheres pressure in small glass tubes surrounded by oxygen boiling *in vacuo*, it condensed to colorless drops.

These noteworthy results are triumphs of physics rather than of chemistry, but no review of chemical progress can afford to omit them; their bearing on the molecular theory of matter justifies the space given them. It seems probable, moreover, that every known substance on the face of the earth will be eventually obtained in solid form by the mere withdrawal of heat. At these low temperatures the chemical activity of bodies is greatly lessened or ceases, but additional observations must be made on this point before attempting generalizations.

Experiments of the character described demand great resources and are not devoid of danger; those conducting them will be rewarded by undying fame.

(15.) The progress of chemistry in its more material aspects is characterized by the improved and economic production of known substances, by the discovery and manufacture of entirely new ones, and by novel applications of both these classes as well as of waste materials. The necessity of utmost condensation precludes enumeration of even a centesimal part of the processes and products, nor would the mere catalogue be profitable. Omitting for the present the prolific department of organic chemistry, brief mention may be made of improvements in the metallurgy of nickel [50] (now known to be malleable and ductile), of attempts to cheapen the production of aluminium,[51] of the revival of the barium dioxide process for manufacturing oxygen on a large scale,[52] of novelties in artistic keramics, of the industrial production and application of the rare metal vanadium, of the successful introduction of water gas as an illuminating agent, and of constant activity in the fascinating field of photography.

No chemical manufactures are more important than those grouped under the name: "Alkali industry," which comprises the production of those adjuncts of civilization, carbonate of soda, caustic soda, bicarbonate of soda, and bleaching powder. Conducted by the methods originated by the ill-fated Nicolas Leblanc, they have, after a century's successful career, begun to give way to a youthful rival. The struggle to maintain the supremacy of Leblanc's process has been severe, the problem being a purely financial one. At first, the profits were made exclusively on the soda, then the decreasing profits, as well as the necessity of condensing the torrents of hydrochloric acid, led manufacturers to add to the production of alkali that of bleaching powder, and the latter then yielded the profits while the soda became a bye-product. Sharp competition in England and France pushed prices below profitable production, and capitalists with millions involved found their chemical ingenuity severely taxed. Various economical methods of recovering waste bye-products were adopted, and finally attention was turned to the "burnt ore" or "pyrites cinders" obtained in roasting pyrites for the sulphuric acid; this is now treated for copper, silver, and, to some extent, for gold. A Spanish company owning enormous deposits of pyrites on the Rio Tinto, plan to establish in France alkali works with the intention of deriving their profits solely from the residual oxide of iron and the copper.

Forty-eight years ago alkali manufacturers might have seen a cloud arising, no bigger than a man's hand, which gradually grew darker and heavier, and now threatens to overwhelm the Leblanc process. Dyer and Hemming patented the so-called "ammonia process" for manufacturing soda in 1838; Schlössing and Rolland attempted to carry it out practically in 1855, but it was not found profitable. The credit of overcoming the practical difficulties, and placing the process on an economical basis, belongs to Solvay, of Brussels, who began to manufacture so-called "ammonia-soda" in 1866. Commencing with the modest yield of 179 tons in that year, he increased it in ten years to 11,580 tons, and in 1883, about 40 per cent of all the soda made on the continent was produced by the ammonia process. The success of the new process has completely killed the Leblanc method in Belgium, and has caused the closing of many works in England. A drawback to the new process is that no hydrochloric acid is produced, yet chloride of lime is always in demand; hence a high authority, Dr. Lunge, thinks that in the future the two processes will, of necessity, exist side by side.[53]

(16.) In modern chemical literature by far the greatest amount of space is occupied with researches and discoveries in organic chemistry. To the non-professional reader the peculiarly technical language, abounding in words of unusual length, is not only incomprehensible, but positively forbidding. A vocabulary which contains such terms as toluyldiphenyltriamidocarbinol acetate and methylorthomonohydroxybenzoate does not encourage the casual reader; and when he learns the first-named body is the dye-stuff commonly called magenta, and that the second is the innocent oil of wintergreen, surprise gives way to feelings of despair. When one is gleefully informed that a distinguished foreigner has discovered that orthobrombenzyl bromide treated with sodium yields anthracene, which, heated with nitric acid, yields anthraquinone, and that anthraquinonedisulphonic acid fused with potassium hydroxide furnishes dioxyanthraquinone, the lay hearer can hardly be expected to become enthusiastic over the announcement, and yet these operations conducted in the private laboratory of a man of genius have been of direct benefit to mankind, setting free thousands of acres for the production of breadstuffs, and establishing industries employing a multitude of workmen. In a word, these abstruse phrases describe the artificial production of alizarine, the valuable coloring matter of madder.

The polysyllabic nomenclature now prevailing expresses to the chemical mind the innate structural composition of the body named; of late years the words are formed by joining syllables to an almost indefinite extent, and a distinguished chemist has recently urged the advantages of empiric names in place of the unwieldy system. Whether Dr. Odling's plea will produce a reaction in favor of empiric names remains to be seen.[54]

(17.) To enter into details concerning the recent progress of organic chemistry, and to make them intelligible to an audience not composed of well-read professional chemists, is an undertaking of doubtful success; we shall content ourselves chiefly with generalities.

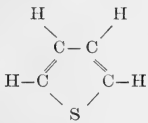
That remarkable product of nature, petroleum, continues to occupy the studies of chemists at home and abroad. Newly invented methods of fractional distillation have disclosed previously unsuspected constituents and peculiarities. Lachowitz has found in the petroleum of Galicia several members of the aromatic series;[55] Mendelejeff has noticed abnormal relations between the specific gravity and boiling-points of successive fractions in distilling American petroleum.[56] The various commercial products from crude petroleum, rhigolene, vaseline, paraffin, etc., continually find new and useful applications, their names being household words.

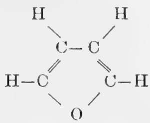
The industrial and scientific novelties in the important groups of oils and fats, alcohols, and acids, cannot be specified. After cane-sugar, glucose is receiving the most attention; in the U. S. and Germany are sixty manufactories of the various grades of starch-sugar, the annual home production alone being valued at $10,000,000. Glucose is extensively used as a substitute for cane-sugar in the manufacture of table syrup, in brewing, in confectionery, in making artificial honey, and in adulterating cane-sugar, as well as in many minor applications. Recent experiments by Dr. Duggan,[57] of Baltimore, show that glucose is in no way inferior to cane-sugar in healthfulness. Much work has been done on sorghum by Dr. Peter Collier,[58] and the first complete examination of maple-sugar has lately been made by Prof. Wiley,[59] of the Department of Agriculture. Lovers of the latter sweet will be pleased to learn that it can be made by adding to a mixture of glucose and cane-sugar a patented extract of hickory bark which imitates the desired flavor.

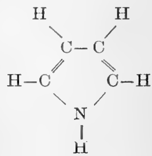
The great demand for high explosives as adjuncts to engineering, mining, and military operations, occasions constant experimentation; besides the invention of mere empiric mixtures of known substances, chiefly nitro-compounds, much work is done of a purely scientific nature, such as investigations on the chemical reactions and products of explosive mixtures, on the heat disengaged by their explosion, on the pressure of the gases produced, and on the duration of the explosive reaction. Thanks to the "Notes" of Prof. C. E. Munroe[60] of the U. S. Naval Academy, chemists are informed of the freshest novelties in this department, rendering further mention superfluous.

(18.) The researches of chemists in the aromatic series outweigh in both number and importance those in all other sections. The once despised refuse coal-tar has created an entirely new chemistry, and, in its products and derivatives, is by far the most promising field for investigators. The compounds of the aromatic series have afforded some of the most notable successes in synthetical chemistry, as well as some of the most useful substances for dyeing, for hygienic and medicinal purposes. The oil obtained in the dry distillation of bones, a subject of classic investigations by Anderson,[61] of Glasgow, forty years ago, has recently acquired new interest; one of its constituents, pyridine (C_6H_5N), has been obtained in several ways, which show that it bears the same relation to certain acids derived from natural alkaloids, such as quinine, nicotine, etc., that benzene does to benzoic and phthalic acids. These facts point to the possible artificial preparation of quinine at no distant day. This view of the constitution of the alkaloids is confirmed in many ways, notably by Ladenburg's discovery that piperidine, a base occurring in pepper, is hexahydrobenzene.[62]

The discovery, by Victor Meyer,[63] of thiophene, a constituent of coal-tar benzene, having sulphur in its composition, is of more than passing interest. Meyer assigns to thiophene a structural formula, which shows its analogy to furfuran and to pyrrol. This is indicated in the following graphic formulæ:

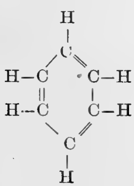

Thiophene.

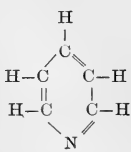

Furfuran.

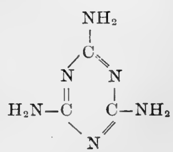

Pyrrol.

(19.) Professional chemists note with interest the important avenues of research opened up by the extension of the so-called ring structure of carbon compounds, and by the introduction of elements other than carbon into the closed chain of atoms. The demonstration by Kekulé, in 1865, that benzene contains a group of carbon atoms joined in such way as to form a regular hexagon, has wonderfully advanced our knowledge of the complex bodies in the aromatic series.

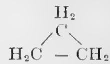
Numerous bodies are now known whose structure is expressed by closed chains of three, four, five, and six links. Dewar[64] was the first, we believe, to show that nitrogen can replace one of the carbon atoms of a six-link chain in pyridine, and Hofmann[65] has shown that three atoms of nitrogen and three of carbon unite to form a closed chain in melamine :

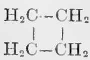
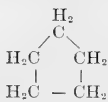
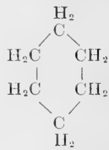

Benzene.


Pyridine.


Melamine.

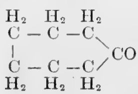
It has been a matter of surprise that no series intermediate between the open chains of the paraffin group and the closed ring of the benzene group have been made known. Quite recently, W. H. Perkin, Jr.,[66] in a remarkable memoir, has begun to fill up this wide gap, and he describes many bodies containing a three-carbon atom ring, a four and a five-carbon atom ring. The series of possible methylene-addition products is shown in the following schedule:

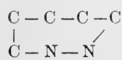
Methylene.	Di-methylene.	Tri-methylene.
$=CH_2$	CH_2 ‖ CH_2	

Tetra-methylene.	Penta-methylene.	Hexa-methylene.
		

For details concerning derivatives of the above series, and the remarkable properties of some, we must refer to Perkin's published papers.

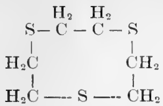
Professor Victor Meyer[67] has, within a few months, begun to investigate the possibility of obtaining closed chains containing a greater number of chains than six. He points out that, with the exception of the double rings, such as anthracene and acridine, only two bodies were known having seven links in a closed chain, viz.:

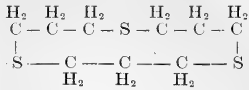




Suberone and Carbazostyril.

Professor Meyer, however, obtained bodies having nine and twelve links in closed chains, as indicated below.





These are substances of little stability, as indeed might be expected.

Professional chemists also acknowledge the marvellous success in unravelling the complications of isomerism, and the important aid afforded the study of isomeric bodies of the aromatic group by the doctrine of *orientation*. These rather technical details can receive, however, but brief mention, though a whole series of lectures could be devoted to the fascinating topic. Leopold Gmelin, when writing his "Handbook of Chemistry," in 1827, requested organic chemists to stop making discoveries, or else he could never finish! And during the sixty years which have elapsed, the activity in organic chemistry has been unceasing; yet the extraordinary number of facts now known is not so great as those which the prophetic eye sees disclosed by these recently revealed lines of investigation.

(20.) The crowning glory of chemistry is the power of producing, in the laboratory, from inorganic matter, substances identical with those existing in the vegetable and animal kingdoms. Belief in the mysterious vital force operating in living beings received a rude shock at the hands of Wöhler, sixty years ago, and successive triumphs in synthesis have dispelled it entirely, so far as non-organized bodies are concerned: "to-day we know that the same chemical laws rule animate and inanimate nature, and that any definite compound produced in the former can be prepared by synthesis as soon as its chemical constitution has been made out." Within a few years chemists have announced the synthesis of many acids, essential oils, alkaloids, glucosides, dye-stuffs, and other bodies naturally occurring in the organic world, and so rapidly do these announcements succeed one another that expectation has displaced surprise. Noteworthy are the following: alizarine, the valuable coloring matter of madder;[68] vanilline, the aromatic principle of the vanilla bean;[69] cumarine, the aromatic principle of the tonka bean;[70] indigo, the well-known dye-stuff;[71] uric acid, an animal product;[72] tyrosin, likewise a product of the animal organism;[73] salicine,[74] daphnetine and umbelliferone,[75] natural glucosides and related bodies; piperidine,[76] a constituent of pepper; and cocaine, the new anæsthetic.[77] Besides these, many syntheses have been accomplished of bodies isomeric and not identical with the natural products.

The alchemists labored to transmute base metals into noble ones, and were destined never to realize their ambitious designs; modern organic chemists, operating on substances compared with which even the base metals are precious, produce articles more beneficial to mankind than gold itself, and, at the same time, gain, indirectly, no small store of the coveted metal.

(21.) The application of chemistry to physiology encounters the most complex and difficult problems in the science, and at the same time aims to accomplish the most beneficent results. "The physiologist complains that probably ninety-five per cent of the solid matters of living structures are pure unknowns, and that the fundamental chemical changes which now occur during life are entirely shrouded in mystery. It is in order that this may no longer be the case that the study of carbon compounds is being so vigorously prosecuted." [78] It may seem strange to the non-professional in this audience that, in spite of persistent and skilful attempts to solve the problem, chemists are obliged to admit ignorance of the exact composition of so common a substance as the white of egg, yet until they acquire an accurate knowledge of the constitution of albuminous substances, the processes of animal economy cannot be explained. While the physiologist, in some degree, waits on the organic chemist for further developments, the latter discovers and prepares novel bodies much faster than the physiologist ascertains their influence on the animal economy. To the joint labors of chemists and physiologists are due the blessings of anæsthetics, hypnotics, and other conquerors of suffering and disease. The anæsthetic properties of cocaine, and the circumstances of their discovery are matters of popular knowledge. Within a twelvemonth, ethylurethane has been added to the list of hypnotics.

In recent years, sanitary chemistry has acquired great importance, and now occupies a distinctly defined field, including all that pertains to the hygienic value of foods and beverages, their adulterations, and their fraudulent substitutes ; questions of gas and water supply ; of the uses and abuses of disinfectants ; of household ventilation, and of the diverse matters grouped under the term chemical engineering. Of this very practical branch of chemical science, as well as of the valuable additions to materia medica, of the improved methods introduced into analytical chemistry, and of the ever increasing contributions to the chemistry of agriculture, no mention can be attempted.

(22.) The tendency of modern researches in chemistry is to magnify the atomic theory; the rapid accumulation of facts, the ever increasing ingenious hypotheses, the most searching examinations of co-ordinate laws, all tend to strengthen the Daltonian adaptation of the philosophic Greeks. Here and there a voice is raised against the slavish worship of picturesque formulæ; but against the molecular theory underlying the symbolic system so depicted, few earnest arguments are advanced. The whole aim of organic chemistry is directed to the discovery of the arrangement of atoms within the molecule, and the success obtained justifies the hypothesis. The edifice erected through these achievements, though young in years, is too substantial to tolerate displacement of its corner-stone. The absolute truth of the atomic theory is beyond man's power to establish; even admitting that it necessitates absurd assumptions, it is, nevertheless, indisputably the "best existing explanation of the facts of chemistry as at present known."

A noteworthy feature of existing chemical research is the recognition of the necessity of a more intimate knowledge of the connection between physical characters and chemical constitution. In the past, chemists increased the number of new compounds so rapidly, that they often neglected detailed examination of their physical properties, their relations to known bodies and to each other, preferring to satisfy their ambition by fresh discoveries. This race after new bodies still continues, but parallel with it are zealous investigators striving after a knowledge of the innate qualities and bearings of these same bodies; and the latter class of students is gaining prizes no less valuable than those secured by the former.

Chemists are also recognizing the necessity of a more minute study of the simpler phenomena of chemistry, and it is in this direction they look for many laurels in the future. Priestley's day of great discoveries by the simplest means has in one sense passed; the opportunities for isolating nine new gases, or of recognizing by chemical tests half a dozen new elementary bodies in the space of a lifetime, are gone; only by the employment of the most delicate appliances, by the closest scrutiny of phenomena and the conditions governing them, by availing themselves of all the resources of physics, by an unshrinking expenditure of time and of money, to say nothing of the necessity of trained mental powers of no low order and of skilled hands, shall chemists in succeeding generations realize their ambitious designs.

NOTES AND AUTHORITIES.

(1.) The membership in these Societies is distributed as follows:

Deutsche chemische Gesellschaft zu Berlin	2,950
Society of Chemical Industry (England)	2,000
Chemical Society of London	1,500
Société chimique de Paris	560
Institute of Chemistry of Great Britain and Ireland	430
American Chemical Society	250
Society of Public Analysts (England)	180
Chemical Society of St. Petersburg	160
Associazione chimico-farmaceutica fiorentina	*200
Chemical Society of Tokio, Japan	83
Chemical Society of Washington, D. C	48
Association of Official Agricultural Chemists (U. S. A.)	17
Total	8,378

(2.) *New Elements Announced Since* 1877.

DATE.	NAME.	SOURCE.	DISCOVERER.
1877	Davyum	Platinum ores	Sergius Kern.
	Neptunium	Columbite	Hermann.
	Lavœsium	Pyrite	Prat.
	Mosandrum	Samarskite	J. L. Smith.
1878	"New earths"	Unnamed mineral.	Gerland.
	Philippium	Samarskite	Delafontaine.
	Decipium	Samarskite	Delafontaine.
	Ytterbium	Gadolinite	Marignac.
	"X."	Gadolinite	Soret.
1879	Scandium	Gadolinite	Nilson.
	Norwegium	Gersdorffite	Dahll.
	Samarium	Samarskite	Lecoq de Boisbaudran.
	Uralium	Platinum	Guyard.
	Barcenium	Misapprehension	Editor Wagner's Jahresb.
	Thulium	Gadolinite	Cleve.
	Holmium	Gadolinite	Cleve.
	Columbium	Samarskite	J. L. Smith.
	Rogerium	Samarskite	J. L. Smith.
	Vesbium	Lava	Scacchi.
1880	Comesium	......	Kaemmerer.
	Yα and Yβ	Gadolinite	Marignac.
1881	Actinium	Zinc ores	Phipson.
1882	Di β	Gadolinite	Cleve.
1883	Nameless	Platinum ores	Th. Wilm.
1884	Idunium	Lead vanadate	Websky.
1885	Neodymium	Didymium	Welsbach.
	Praseodymium	Didymium	Welsbach.
	Zα	Didymium	Lecoq de Boisbaudran.
	Zβ	Didymium	Lecoq de Boisbaudran.
1886	Zγ	Terbia	Lecoq de Boisbaudran.

* Estimated. Many chemists are members of several of the above societies, but against this duplication may be set those not connected with societies.

(3.) Chem. News, XLVII., 261 (1883).
(4.) Chem. News, LI., 301 (read to Royal Society June 18th, 1885).
(5.) Comptes rendus, C., 1437 (June 8th, 1885).
(6.) F. W. Clarke. A Recalculation of the Atomic Weights. Part V., Constants of Nature. Smithsonian Institution. Washington, 1882.
(7.) L. Meyer und K. Seubert. Die Atomgewichte der Elemente aus den Originalzahlen neu berechnet. Leipzig, 1883.
(8.) Ber. d. chem. Ges., XVIII., 1089 (1885).
(9.) Am. J. Sci. (3), XXVI., 63 and 310 (1883).
(10.) John A. R. Newlands. On the Discovery of the Periodic Law, and on Relations among the Atomic Weights. London, 1884.
(11.) Liebig's Annalen. Suppl. Bd. VIII., 133. Also Chem. News, XL. and XLI.
(12.) Ber. d. chem. Ges., XIII., 1439.
(13.) Chem. News, XLI., 83.
(14.) Sestini. Gazz. chim. ital., XV., 107.
(15.) Thomas Carnelley. Ber. d. chem. Ges., XVII., 2151 and 2287.
(16.) Nature, XXXII., 539 (1885).
(17.) Proc. Roy. Soc., XXVIII., 159, and XXIX., 247 and 266.
(18.) Pop. Sci. Monthly, New York, Feb., 1876, p. 436.
(19.) Chem. News, LII., 49 (1885).
(20.) Chem. News, LII., 34 (1885).
(21.) Ann. chim. phys., XXIII. and XXIV. (1823).
(22.) Ber. d. chem. Ges., XVII. and XVIII.
(23.) Am. Chem. J., VII., 189 (1885).
(24.) Chem. News, XX., 271.
(25.) Nature, XXVIII., 551, and Chem. News, XLVI., 151.
(26.) Chem. News, LI., 150 (1885).
(27.) Chem. News, LII., 135 (1885).
(28.) Meyer und Langer. Pyrochemische Untersuchungen. Leipzig, 1885.
(28A.) Wurtz Dictionnaire, I., 220.
(29.) Comptes rendus, XX., 817 (1844).
(30.) Chem. News, LI., 27.
(31.) Cf. Pattison Muir. Principles of Chemistry. Cambridge, 1884.
(32.) Chem. News, XLVI., 151.
(33.) Ber. d. chem. Ges., XVIII., 1890 (1885.)
(34.) Since writing the above, Dixon has read another paper on the subject, in which he rejects Traube's views. Nature, XXXIII., 286 (1886).
(35.) The decomposition of potassium chlorate affords another case in point. The exact manner in which heat affects this salt is yet under discussion. See Dr. Teed's results in Chem. News, LII., 248 (1885), and LIII., 56 (1886). And compare Maumené, Bull. soc. chim., XLV., 51 (1886).
(36.). Wurtz Dictionnaire de chimie, art. *Affinité*.
(37.) Proc. Roy. Soc., XIX., 498.
(38.) Proc. Am. Assoc. Adv. Sci., XXXIII., 185 (1884.)
(39.) Idem, p. 141. Cf. R. B. Warder. Proc. Am. Assoc. Adv. Sci., XXXII., 156.
(40.) Wurtz Dictionnaire, art. *Thermochimie*.
(41.) Essai de mécanique chimique. Paris, 1879, 2 vols.
(42.) Thermo-chemische Untersuchungen. Leipzig, 4 vols., 1882–'86.
(43.) J. W. Langley. Proc. Am. Assoc. Adv. Sci., XXXIII., 153.
(44.) Pattison Muir. Principles of Chemistry. Cambridge, 1884, p. 306.

(45.) Comptes rendus, LXXXV., 1214 and 1220.
(46.) Ann. chim. phys. [5], XV., 132.
(47.) Comptes rendus, XCVI., 1140 *et seq.*, and Chem. News, XLIX., 13. Also Comptes rendus, XCVIII., Jan. 28th, 1884.
(48.) Olzewski. Comptes rendus, C., Feb. 9th, 1885.
(49.) Chem. News, LII., 201 (1885).
(50.) Fleitman in 1879. Cf. Chem. News, L., 3 (1884).
(51.) Dingler's polyt. J., 1882.
(52.) Nature, XXXII, 354 (1885).
(53.) Chem. News, XLVII., 67, and L., 41.
(54.) Nature, XXXII.
(55.) Liebig's Annalen, CCXX., 168.
(56.) Protok. Russ. phys. chem. Ges., 1884, 458.
(57.) Report on Glucose, prepared by the National Acad. Sci. U. S. Internal Revenue. Washington, 1884.
(58.) Sorghum, its Culture and Uses. Press of the Chamber of Commerce. New York, 1885.
(59.) Sugar Industry of the United States. Dept. Agriculture, Chemical Division, Bulletin No. 5. Washington, 1885.
(60.) Notes on the Literature of Explosions, in Proceedings U. S. Naval Institute, Nos. 20, 21, 22, 24, 27, 29, 32, 33.
(61.) Trans. Roy. Soc. Edinburgh, XVI. (1849), and XX. (1851).
(62.) Ber. d. chem. Ges., XVII., 514 (1884).
(63.) *Idem*, XV., 2893, and XVI.
(64.) Zeitschr. f. chem., 1871, 117.
(65.) Ber. d. chem. Ges., XV.
(66.) Journ. Chem. Soc., London, 1885.
(67.) Naturwiss. Rundschau, I., 1. (1886).
(68.) Graebe und Liebermann. Liebig's Annalen, Suppl., Bd. VII., 300.
(69.) Tiemann, Ber. d. chem. Ges., VII., 613.
(70.) Perkin, Liebig's Annalen, CXLVII., 230.
(71.) Baeyer, Ber. d. chem. Ges., III., 515.
(72.) Horbaczewski, Ber. d. chem. Ges., XV., 2678.
(73.) Erlenmeyer and Lipp, Ber. d. chem. Ges., XV., 1006 and 1544.
(74.) Arthur Michael, Am. Chem. J., V., 171.
(75.) von Pechmann, Ber. d. chem. Ges., XVII., 929.
(76.) Ladenburg and Roth, Ber. d. chem. Ges., XVII., 514.
(77.) Merck, Ber. d. chem. Ges., XVIII., 2264.
(78.) Dr. Armstrong.

March 22, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

One hundred and two persons present.

MRS. ERMINNIE A. SMITH read a paper on

SIGNIFICANCE OF FLORA TO THE IROQUOIS.

DISCUSSION.

MR. L. E. CHITTENDEN referred to the possible importance of the study of vegetable remedies of the Indians.

PROF. O. P. HUBBARD spoke of the history of the Tuscaroras; of their removal from Virginia and union with the Six Nations. He stated that this tribe successfully performed upon their captives, customarily, a surgical operation upon the foot, now known among surgeons as Hey's operation.

MRS. SMITH thought the medical knowledge of the Indians was very slight.

PRESIDENT NEWBERRY said that he had visited over forty Indian tribes in the United States, Mexico and Canada, and being especially interested, as a physician, in their remedies, he had made many observations and inquiries upon the subject. He regarded Indian medical practice upon the whole as being a humbug. The Indians esteem many aromatic plants, but these have usually little value. Rarely their vegetable remedies have some utility. For example, the Pueblos now use a root with good effect for scrofulous ulcers and obstinate wounds. No remedy is known among the Indians for rattlesnake bite. The Wild Indigo is used for this, but its efficacy is not proven. Many tribes of Indians have a heroic remedy which consists in causing a profuse perspiration, in their "sweat-house," and then plunging into cold water. The shock thus produced may sometimes have been effective for good, oftener for evil. Among the Utes he had observed a novel method of producing vomiting, by exposing the bare stomach to the hot sun. The exposed life of the Indian is conducive to vigor, and he is rarely sick. But when he does fall sick, like a horse or dog, he generally dies.

PROF. TROWBRIDGE related his experience among the Indians of Cape Flattery, and gave an account of an almost fatal trouble produced by breaking the rule of never prescribing medicine for an Indian.

He believed that no Indian tribe had, as a whole, been the first party to break a compact.

PRESIDENT NEWBERRY and MRS. SMITH agreed with PROF. TROWBRIDGE that the Indians had been shamefully abused by the whites, and that nearly all the Indian wars were caused by the latter. They were also agreed that the Indians should have land in severalty, and be brought under the civil law.

March 29, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Twenty-five persons present.

MR. LUCIUS PITKIN read a paper on

THEORIES CONCERNING THE PROTECTIVE INFLUENCE OF MITIGATED VIRUS.

In introducing the discussion of this theme, it may be useful to define, for those not conversant with the subject, the terms "virus" and "mitigation," and also what is meant by "protective influence." The term "virus" is used in this paper as synonymous with disease-producing micro-organism, and while the contagium of *all* infectious diseases is not as yet proven to be of this character, still in some six or seven the proof is absolute, and only such will be used as examples.

Mitigation can be defined as such a modification of the disease germ that its inoculation into a susceptible animal will produce a disease very much milder than the original form—sometimes an almost imperceptible temporary effect. The degrees of mitigation are numberless, varying from almost the original virulence to the germ totally innocuous. The methods of mitigation, while numerous, all depend upon surrounding the germ with unfavorable environment, so that its vitality is lowered. That animals susceptible to anthrax lose in a majority of cases this susceptibility by inoculation with mitigated virus, is no longer a question. The same is true in regard to the cholera of fowls. The facts are undisputed. The method has its dangers, and may be found inexpedient. The protective influence may not be so permanent as believed by some of its advocates, but with that we are not now concerned. The sole object of this paper is to critically examine the theories which have been brought forward to explain the "wherefore" of the protective influence which has been proved to exist.

It is obvious that, besides the phenomenon of protection by mitigated virus, there is a correlated phenomenon which must likewise be explained by any theory, and this is the protection afforded in many cases by a previous attack of the same disease. This, however, is easily met by all the theories, since a previous attack, on the germ theory of disease, is in reality equivalent to inoculation with a virus not sufficiently powerful to kill. An interesting question, which has suggested itself, is the immunity of an individual to a particular disease after suffering from some other disease. Had we the history of enough individuals, we would possibly find, on tabulating the statistics, that the occurrence of a special disease had protected in a considerable degree against some other disease, not, perhaps, to the degree noticed in protection from subsequent attacks of the same disease, but enough to clearly show in the average a protective influence.

This may possibly have been noticed where the diseases are of the same character, differing only in intensity; but between diseases of different characters it has not, I think, been made a subject of investigation from statistics. There is nothing in any of the theories to be advanced which would theoretically militate against such being the case, while in some inoculation experiments, animals previously treated, but not with the virus at that time being studied, have seemingly been less susceptible than perfectly fresh subjects.

Here, then, is a subject which may repay a little tabulation by those having access to the required records.

Three main theories have been advanced to explain immunity, which can be named most conveniently by their distinguishing characteristics, as:

1st. The "exhaustion" theory, followed by Pasteur.

2d. The "antidote" theory, of which a discussion, avowedly in its favor, can be found in Klein's recent "Micro-organisms and Disease;" and

3d. What I wish to call the "tolerance" theory, first put forward, I believe, by Sternberg.

Let us consider each in its turn.

The "exhaustion" theory is the first which would by its simplicity be apt to be thought of. Its analogies with the conceptions previously guiding the germ theory are most close. To Pasteur, working for many years on Fermentation, it would naturally occur; it is this: The blood and tissues of an animal contain certain substances necessary to the life and multiplication of the disease germs; such substances are removed by the germs either of mitigated virus or of the disease itself, and thus the animal is protected against subsequent attacks, since the supply of this particular aliment is wanting, and without it the germ cannot thrive. The apparent analogy to alcoholic fermentation is very striking. There we know the presence of a particular substance (sugar) is necessary to the life and multiplication of the germ (yeast plant); that this substance serves as food to the germ, is thus removed, and after removal the liquor cannot again undergo fermentation of the same kind, since the supply of aliment is wanting. We have seen how the germ theory has gone hand in hand with fermentation, and it is to the greatest worker in ferments that we owe this theory. But is it tenable? We do not think it is.

We will quote Pasteur's own words in its defence, and then discuss his statements. He says: "The explanation to which these facts lead us, as well of the constitutional resistance of some animals, as also of the immunity which protective inoculation gives rise to in fowls, is nothing else but natural when we consider that every culture in general modifies the medium in which it is effected; a modification of the soil in the case of ordinary plants; a modification of plants or animals when it relates to their parasites; a modification of our culture liquids when it relates to mucedines, vibrioniens, or ferments. . . . If one sows chicken bouillon with the microbe of fowl cholera, and after three or four days filters the liquid to remove every trace of the microbe, and afterwards sows anew this parasite in the filtered liquid, it will show itself totally impotent to resume the most feeble development. Perfectly limpid after filtration, the liquid retains this limpidity indefinitely. How is it possible to doubt that by the culture of mitigated virus in the fowl, we place its body in the state of our filtered liquid, which can no longer sustain the microbe?"—*Comptes Rendus Acad. des Sciences*, XC., 975.

First then, his statements are correct, but the analogy is more apparent than real.

For this theory requires a peculiar substance for each disease, or at least for every disease which protects against subsequent attacks. Of what nature is this substance? According to the examples given by Pasteur, it appears as an alimentary substance. If so, it must be present in the body in considerable amounts, for the germs, though infinitely small, are infinitely numerous, and the proportion of inorganic matter extracted from the soil by a particular plant, like tobacco, which requires frequent rotation, or the amount of organic matter removed from solution in chicken bouillon, is very large. Whatever we consider this to be, multiply it by the number of infectious diseases not inhibiting one another, and we obtain a conception of the amount of these substances required.

Again notice that these substances, whatever their character or composition, are bodies having no office that we know of in the usual economy of the system. If they were, a man, after an attack of a certain disease, and while possessing immunity from it, would be deprived of a substance necessary to the system, which would speedily show its defective organization.

Still again, we know of the speedy elimination from the system of all bodies not figuring in the general economy, except in those cases where some morbid action induces at the same time a constant supply to meet this drain.

Considering these facts, is it not strange that such a variety of substances, foreign to the normal working of the system, should be formed in it, and that, contrary to the usual rule, these substances should be able to withstand the natural tendency of the system toward the removal of effete matter until such time as the disease germ by its multiplication removes them?

Add to this that an infusion of the tissues of an animal, after inoculation (which has recovered and enjoys immunity from a disease, and from which, on Pasteur's theory, the pabulum necessary for that disease germ has been exhausted), forms a suitable culture medium for the germs of that disease, and we have a very strong case against this theory.

The exhaustion of chicken bouillon, so that it will not support the new cultivation of fowl-cholera microbe, simply means that too much of the proteid constituents in solution have been removed in the life processes of the previous cultivation to allow the fluid to act as suitable pabulum for the new crop.

Let us now examine the second of the theories proposed, the "antidote theory" of Klein, enlarged upon in the twentieth chapter of his book previously mentioned, where he thus defines and explains it: "According to this (theory), the organisms growing and multiplying in the body during the first attack produce, directly or indirectly, some substance which acts as a sort of poison against a second immigration of the same organism. . . . According to this theory, we can well understand that—just as in the case of an animal, say a pig, unsusceptible to anthrax, the unsusceptibility being due to the presence in the blood and tissues of a particular chemical substance inimical to the growth of the bacillus anthracis—so also in the case of a sheep or ox which has once passed through anthrax, there is now present in the blood and tissues a chemical substance inimical to the growth and multiplication of the bacillus anthracis, whereby these animals become possessed of immunity against a second attack of anthrax. Whether this chemical substance has been elaborated directly by the bacilli, or whether it is a result of the chemical processes induced in the body by the bacilli during the first illness, matters not at all; it is only necessary to assume that the blood and tissues of the living animal contain this chemical substance." So much for Klein in behalf of this theory, concerning which he says: "I am inclined to think that this theory is in harmony with the facts." Let us examine upon what foundation it rests.

In the beginning we remark that, while rendering necessary a certain number of hypothetical substances to act as antidotes against subsequent invasions of germs of the same character, it is, if I may so call it, "quantitatively" superior to Pasteur's theory, inasmuch as we can conceive of smaller quantities of these chemical poisons being capable of prohibiting the growth of micro-organisms than the amount of substance necessary to sustain them; and where a substance is hypothetical, the smaller the amount the better defence has it from the question, "Why has it not been found?"

Still, in common with Pasteur's, it has the defect of necessitating hypothetical substances, while, on the other hand, we have to admit that chemistry has not as yet sufficiently investigated the subject to decisively negative their existence.

There can be no doubt that the cause of this immunity after inoculation, or after one attack of a disease, is in some measure connected with the fact of the immunity of certain animals from particular diseases. Thus the hog or carnivorous animals are not affected by the bacillus of anthrax, so deadly to the herbivora. Klein is very much justified in believing that this is largely due to difference in the chemical constitution of the blood, but does not, I think, dwell sufficiently on other conditions, like temperature, degree of oxygenation, etc., which, apart from difference in chemical constitution, make the blood and tissues of certain animals quite different culture media.

It will be remembered that, in the extract quoted from Klein, this particular case of the unsusceptibility of the pig is taken as an analogue of the state of a sheep or ox after once having an attack of anthrax. I would call the attention of Dr. Klein to what may be an unconscious, but what is most certainly a radical shifting of his ground, under the necessities forced on him by the adoption of this theory, if he really intends that these two cases should be considered similar, and that his expression ("just as in the case of an animal, say a pig, ... so also in the case of a sheep or ox") should be taken literally.

That they are not similar, upon his theory of protection, appears from an analysis of his remarks on pages 178, 179, and 186 of his book.

There he says: "The tissues and juices of a pig, when obtained as infusion or otherwise, are just as good a nourishing material for the bacillus anthracis as the tissues and juices obtained from an herbivorous animal," and "there remains, therefore, only one thing; that is, there is something or other present in a particular tissue, to which this latter owes its immunity, and this something must, of necessity, be connected with the tissue while alive;" and lastly, "this inhibitory power is due to the presence of a chemical substance produced by the living tissue." Granting for the argument (though we do not in reality) the truth of this explanation, is it similar to protection after vaccination, on the hypothesis favored by Klein? Clearly not. What must be the nature of the substance inhibiting anthrax in pigs to satisfy these last quotations?

It must be produced by the living tissue in such small amounts at a time that blood introduced into a culture flask direct from the veins does not contain enough to inhibit the growth of the bacillus; it must, therefore, to be effectual for this purpose, be constantly elaborated and constantly destroyed, and in its elaboration prevent the multiplication. This last is probably what Dr. Klein adheres to, since the substance, if stable and in large enough quantity to prevent disease in the animal, would exercise a deterring influence in cultivations outside of the body, and, if not stable, would have to be constantly renewed to keep up the immunity. It is then, like all the other constituents of the blood and tissues, constantly elaborated and constantly destroyed, the normal life action keeping it present in the right proportion. This substance, then, can rightly be called normal to the blood of a pig. Is it such a substance that Dr. Klein believes prevents a second attack of disease in an animal susceptible to a first? His definition of such immunity negatives it; besides, he devotes a special paragraph to tell us distinctly it is not. To refer to his definition, the first quotation from him states immunity after inoculation to be due to a substance produced by the organisms growing and multiplying in the first attack, which acts as a poison towards a second immigration. This production, however, is qualified by the words "direct or indirect," which are afterwards explained by the sentence, "Whether this chemical substance has been elaborated directly by the bacilli, or whether it is a result of the chemical processes induced in the body by the bacilli during the first illness, matters not at all." Here then it is plain that Klein would have us believe that the substance inhibitory in acquired immunity, as compared with natural immunity, is formed and kept stored in the former case, while constantly replenished in the latter, and it is for this reason I have denied the similarity of the two phenomena on his hypothesis.

In discussing Pasteur's theory (the exhaustion theory), Klein states that "there is absolutely no ground for the assumption that if an infusion of the tissues of an animal (protected against anthrax by inoculation) were made, the bacillus anthracis would not thrive in it luxuriantly;" but surely this is equally an argument against Klein's own theory unless, indeed, he would claim that the process of making an infusion destroyed his hypothetical inhibitory substance. If this claim be made, dare he assert that blood directly from the circulation of a protected animal will not support the multiplication of the bacillus? We think the whole tenor of his work is against such a supposition. But if it will not in a culture flask, why will it in the body?

Again, all we know of the economy of the system precludes the idea that such a substance could long resist the various processes of absorption and elimination, and, as it is organic, we may mention the possibility of oxidation in the circulation.

The foundation of this whole theory lies in the observed fact that some putrefactive organisms have been found to produce in their life-processes alkaloidal and aromatic products of decomposition inimical to their own further multiplication, as indol, skatol, phenol, and sepsin. It may be mentioned, however, that while these substances are in certain proportions inimical to the growth of micro-organisms, they seem much more so to man himself, and it is more than probable that a proportion sufficiently large in the circulation to inhibit the growth of bacteria would quickly place the man outside the need of protection from any mortal disease. Since, however, the substances produced by them (the pathogenic bacteria) are organic, and of the nature, possibly, of the alkaloids in some cases, I contemplate a study of the effect of solutions of the ordinary alkaloids upon bacterial life. The above facts will, however, show how small the support thus far given to this theory is.

The arguments used against this theory as presented in this paper are so patent that one is almost tempted to ask if there is not some possibility of mistaking Dr. Klein's position; for it is readily seen that if, instead of a poison produced (either by the micro-organisms or by morbid action of the body during their invasion) and subsequently stored, we can assume that the cells of the body have acquired by the disease some new activity or function that would allow them to elaborate it, many of the difficulties would be removed. We have interpreted Dr. Klein as carefully as possible, but to avoid any such question, a few lines from his book will show how far such a theory was from his thoughts.

Thus, speaking of the "antidote theory," the one which he favors, he says:

"Some observers (Grawitz, etc.) are not satisfied with this theory, but assume that, owing to the first attack, the cells of the tissues so change their nature that they become capable of resisting the immigration of a new generation of the same organism. There is absolutely nothing that I know of in favor of such a theory; it is impossible to imagine that the cells of the connective tissues, of the blood, and of other organs, owing to a past attack of scarlatina, become possessed of new functions or of some new power, as, for instance, a greater power of oxidizing or the like. Connective-tissue cells, blood-corpuscles, liver-cells, and other tissues are, so far as we know, possessed of precisely the same characters and functions after an attack of scarlatina as before." To which I would reply that, "so far as we know," the composition of the blood is the same after recovery also. It is because we do not know, that we are seeking to ascertain the most probable theory, and if Dr. Klein is justified in alluding to the meagreness of our knowledge of the chemical constituents of blood of different species, different individuals, and the same person before and after disease, I am justified as a chemist in returning a "tu quoque" and asking how much investigation of the functions and potencies of the various classes of cells under the above variations have been made by physiologists. All that either of us know absolutely in connection with the subject is that an effect has changed, and there must therefore be a variation in the cause. And so I will make bold, in spite of impossibilities of conception, to state the third theory, brought into prominence in America by the writings of Sternberg, and simply say that while this, in common with all, has to suppose some things yet unproved, this, alone of all, is not contradicted by the facts of our present knowledge. It is called by Sternberg a "vital resistance theory," but since vital resistance is recognized even by the advocates of the other theories, and, as considered now, acquired tolerance is the characteristic feature, we will, for our purposes, call it the "tolerance" theory. The theory is simply this: Non-pathogenic organisms differ from pathogenic in that the former are not able to withstand the influence of the healthy tissues of an animal. To what is this difference, admitted by all, due? Probably to the production by the pathogenic organism of some chemical substance not elaborated by non-pathogenic or septic organisms. Here we are not at variance with the majority of observers. What, then, is more natural than that the immunity after a first attack or after inoculation with mitigated virus proceeds from an acquired tolerance to this particular chemical substance. Let it be clearly understood that these disease germs are cells, that they meet in the tissues other cells, that the blood is simply blood-discs, peculiar cells, floating in the serum, and that in disease there is a contest between these different cells. Suppose, now, the disease cells elaborate, as they probably do, certain organic substances deleterious to the cellular constituents of the tissues and blood, is it not very possible, is it not certain, in fact, to a limited extent, that where, in any such combat, the animal cells were victors over the disease germs, the cells would acquire some tolerance to the deleterious substance? Look at the quick tolerance of the cells to organic poisons!

The opium habit can be very quickly acquired, I understand, so that doses fatal to the normal man are almost harmless. Again I understand from smokers that the tobacco sickness experienced with the first cigar protects in some singular manner from subsequent attacks, and these illustrations are exactly to the point, since we are dealing with the acquired tolerance of the system (which is simply an infinitude of cells), or of the cells themselves to organic poisons, and I wish to show that in some cases this tolerance is quickly established. Place now beside this Dr. Klein's, "it is impossible to imagine that the cells of the connective tissues of the blood and of other organs, owing to a past attack of scarlatina, become possessed of new functions or of some new power." This immunity may not be a new function, but it certainly is a new power, and I claim that it is no more impossible to imagine a new power conferred on cells by an attack of scarlatina, namely tolerance, than it is to imagine the acquired tolerance to tobacco. The rationale of each may be impossible to the imagination, but the fact of one is proved.

Admitting then with Dr. Klein that these disease germs, in their life and multiplication, produce organic substances, but here parting company with him, does it seem improbable that this substance in the different cases may exercise a poisonous action on the animal cells, and that there may be a tolerance established if the attack is not fatal?

The theory embraces none of those stumbling blocks of retention in the system of foreign organic matter without elimination and the strange behavior of cultures outside the animal body. We have heard much of "reversion to type," and the question may very fairly be put, if these blood-discs, tissue cells, or whatever of the bodily organism supposed to acquire tolerance, have for many years conformed to a certain type, lacking this tolerance, why should we not expect that as soon as the disease is removed the cells will regain their old condition? The answer is that they slowly do, as witness the vaccination methods and statistics, and we cannot deny a fact because opposed to what we would consider probability. The fact which I have reference to, is that under the nearest possible similar circumstances, we observe the acquired characteristic very persistent; thus take the virus of fowl cholera attenuated as Pasteur prepares it, and yet successive cultures in the ordinary way, each culture representing many generations, show no perceptible difference in the one acquired characteristic, the degree of mitigation. Chamberland and Roux claim also the same result in cultivations of the bacillus of splenic fever.

And again, the tolerance acquired is not of necessity great. In the contest between the disease germs and the normal cells, we are in no wise qualified to say how much or how little will determine the battle for or against health.

In concluding, I will refer to Sternberg's paper in the *American Journal of the Medical Sciences* for April, 1881, and say that he there confines himself to a discussion of Pasteur's theory of exhaustion, as this paper deals more exclusively with the antidote theory. So far as regards Sternberg's own theory, I have abstracted the paper only so far as is necessary to do justice to his views; in the illustrations, and where possible in the arguments, I have endeavored to follow a somewhat different line that the theory may have the advantage of both courses of reasoning.

My reason for using the term "mitigated virus," instead of "attenuated virus," most commonly used, is that mitigation is as nearly as possible the idea in the French word (attenué) while our own word attenuation conveys in ordinary parlance little of the conception of a modification into less severe forms.

April 5, 1886.

Regular Business Meeting.

The President, Dr. J. S. Newberry, in the chair.

Seventeen persons present.

The following persons were elected Resident Members :

Mr. John S. Brownne,
Mr. David S. Banks,
Mr. Lucius C. Ashley,
Mr. Joseph M. Knap.

A paper by Mr. George F. Kunz was read by title :

NOTES ON SOME MINERALS FROM THE WEST.

1. *Celestite from Lampasas Co., Texas.*

Some magnificent celestite in perfect blue crystals has been found recently in a buff-colored limestone, associated with white calcite crystals, in a railroad cutting in Lampasas Co., Texas. They are now in the collection of Mr. Clarence S. Bement. One crystal measures eight inches in length. It is of a fine sky-blue color, and has a high polish on the faces of the crystal. The faces measure 20x13x10 centimetres. Some smaller very sharply defined crystals were also found here.

2. *Topaz and Spessartite from Nathrop, Chaffee Co., Colorado.*

Beautiful brilliant specimens of topaz crystals, with single and double terminations, measuring from five to twenty-five mm. in length, have been lately obtained from the above locality. They occurred in cavities of rhyolite; and with them were beautiful crystals of spessartite, measuring in length from one to six mm.

The spessartite (manganese alumina garnet) is of a translucent rich blood-red color, and its faces are remarkably brilliant, the planes observed being 2–2 and i. In the topaz the faces observed are O, I, i–2̆, 2, 2–ī, i3̆, i–ĭ.

The cavities in which these crystals occur are usually lined with small minute crystals of quartz. Small particles of obsidian were also seen disseminated through the mass.

From the same county have been sent some transparent quartz crystals, two inches in length by one inch across, coated with chlorite, and penetrated in every direction by crystals of byssolite.

DR. H. CARRINGTON BOLTON spoke upon

PEROXIDES OF POTASSIUM AND SODIUM.

A Lecture Experiment.

The peroxide of potassium, K_2O_4, and the peroxide of sodium, Na_2O_2, were known to Gay Lussac and Thénard [1] as early as 1810, by whom they were obtained in minute quantities in various ways. They have been analyzed and closely studied by Vernon Harcourt,[2] who prepared them by burning the respective metals in dry oxygen gas.

I have devised a simple method for exhibiting to a class the formation and some of the characteristics of these peroxides. In a test-tube suspended by a wire from an iron stand, a quantity of potassium nitrate is melted over a Bunsen burner and heated until oxygen gas is freely liberated; on dropping into the melted nitrate small pellets of clean potassium, the metal burns with a bright light, and forms the yellowish peroxide; this gradually sinks beneath the surface of the melted mass and dissolves therein, communicating to the whole a deep, rich, red color; the color is easily shown by the aid of transmitted light. On allowing the melted mass to cool and solidify, the color disappears, but reappears on again applying heat.

If sodium nitrate and metallic sodium be used, similar phenomena are observed, but the solution of the peroxide has a yellowish-red color. The action of sodium on melted saltpetre produces a brown-red solution quite intense when sufficiently heated. On cooling, in each case the mass loses its color.

These reactions are quite consistent with the properties of the peroxides as described by Harcourt; potassium peroxide, he says, is "deep orange-yellow and fuses to a black fluid"; sodium peroxide is white when cold, becomes "full yellow" on heating, and when fused is "black while hot, brown on cooling." Moreover, we prepared a small quantity of sodium peroxide in the usual way, by burning the metal in dry oxygen, and ascertained

[1] Recherches physico-chimiques, i., 132.
[2] Quart. J. Chem. Soc., xvi., 267 (1861).

that it dissolves in melted saltpetre with the characteristic coloration.

The colorless mass resulting from any of the above reactions forms, of course, a strong alkaline aqueous solution; this yields, with copper sulphate, a greenish precipitate which is evidently a mixture of blue cupric hydrate and of the yellow peroxide of copper, formed according to Brodie, when alkaline peroxides react on salts of copper.[1]

On attempting to examine the action of sodium on melted chlorate of potassium, a violent explosion occurred, projecting fragments of the test-tube and the melted salt into the face and over the person of the operator. The explosion was instantaneous and accompanied by a loud report. On repeating this with suitable precautions, using a stouter tube surrounded by a metallic cylinder, similar explosions resulted, without, however, breaking the glass. Pellets of sodium no larger than a grain of barley cause sharp reports the moment they reach the surface of the melted chlorate. Serious accidents might result from incautious experimentation with these materials should the treacherous character of chlorates be overlooked.

As a lecture experiment, the action of potassium on the nitrate is instructive and will do much to dispel the impression, often left on the minds of students, that the alkaline metals form colored compounds only with acids having chromatic radicals.

DR. N. L. BRITTON read a paper entitled :

GEOLOGICAL NOTES IN WESTERN VIRGINIA, NORTH CAROLINA, AND EASTERN TENNESSEE.

(Illustrated with specimens.)

The following observations were made during a recent trip through the southern Blue Ridge and Alleghany Mountains. While there is little, if anything, entirely novel to be found in them, the statement of certain facts and hypotheses may be of some interest to the Academy.

The Great Appalachian valley extends almost uninterruptedly from northern Vermont to Georgia, bounded to the east by a nearly continuous mountain system. The Green Mountains in Vermont and Massachusetts; The Highlands of southern New York and northern New Jersey; the South Mountain in Pennsylvania; the Blue Ridge and portions of the Alleghany Mountain system through Maryland, Virginia, North Carolina, and Georgia are but local developments of what is generally conceded

[1] Proc. Roy. Soc., xii., 209.

to be one vast elongated uplift. The greater part of this is made of crystalline rocks, most probably of Laurentian Age, though the presence of areas underlaid by younger Archæan strata may not be improbable. The western boundary of this valley is found in the Adirondacks of northern New York, also of Laurentian rocks, but farther southwest this margin is made by folds of Palæozoic strata, and of these the Oneida conglomerate, or Shawangunk grit, and Medina sandstone are the most prominent, principally for the reason that, from their greater hardness, they have better withstood the erosion which has cut away the less resistant Lower Silurian limestones and slates which form the floor of the great valley throughout nearly its entire extent. To certain features of these softer rocks I would first call your attention. The Hudson River slate, which ordinarily lies next the Oneida or Medina, though also occurring in detached areas, surrounded by the limestones, is either a true clay slate or a very sandy slate varying to a sandstone, and sometimes designated as gray wacke; locally it becomes appreciably calcareous. When a true slate, which is its general character, it contains but few fossils, as will be seen in the fact that, up to the present time, not a single organism has been detected in it throughout its entire area of several hundred square miles in New Jersey. The limestones which it geologically overlies are, for the most part, magnesian, though some areas of pure limestone are recorded. This dolomitic rock is also very barren of fossils; it may, however, generally be recognized by its lithological and chemical features, which seem to be quite persistent. It has been referred to the Calciferous Epoch of the New York Geologists, and it would be difficult to prove that this is not its horizon. Locally, other fossiliferous limestones occur in the Great Valley, but, taken as a whole, must be regarded as entirely subordinate in amount to that of the magnesian. Underlying this limestone, and always found in greater or less development between it and the crystalline rocks to the east, is a sandstone, or, more generally, quartzite, of immense thickness along the southwestern extension of the valley, less abundant to the northeast, which answers in geological position to the Potsdam of northern New York, and has generally been regarded as of that age.

About Luray, Virginia, located in Page Valley, as the Appalachian Valley is there locally known, the magnesian limestones are seen in many outcrops along the Hawksbill Creek. There appears to be a synclinal fold in the rocks just west of the creek, for along its western bank the dip is 37° W., while 600 feet away the dip is 40° S. E., and about half a mile up the stream they are bedded nearly horizontally. East of these outcrops there is an extensive tract of country covered with loose pebbles and masses of quartzite, and fine grained, dark colored conglomerate. None of this rock was seen in place. It resembles the Potsdam, and there is probably a local fold here which brings this rock to the surface. In the siliceous soil resulting from its decay grow many plants which are abundant on the pre-glacial drift soils of sand and gravel in southern New Jersey and elsewhere along the coast. Among these are *Ascyrum Crux-Andreæ*, *Stylosanthes elatior*, *Quercus nigra*, *Quercus obtusiloba* and *Gnaphalium purpureum*, none of which were seen on the limestone soils to the west.

The famous caverns are situated about a mile west of the railroad station. They have been fully and repeatedly described, and I can add little to what has been said of them. They are in this magnesian limestone, here bedded very flat, dipping on the average perhaps 10° S. E. in very thick strata. The rock is heavily ferriferous, and the ornamentation, which, in one form or another, covers nearly the entire surface of the cave, is mostly somewhat brownish in color, though there are some nearly white columns and pendents. The entire floor is thickly covered with brownish-red clay, reaching a depth of at least four feet in places, which represents the less soluble portions of the limestone. This clay is a prominent surface feature here as elsewhere in the valley, and in several places brick are made from it, the sub-aerial decomposition of the limestone yielding the same or closely similar products as the subterranean decay. Quartz is very scarce in the Luray Caverns; a few crystals are pointed out in the roof near the entrance, and in a few places the siliceous portions of the limestone which have resisted the general erosion of the rock may be seen standing in relief. At present, the cave is very dry; a few pools of water are seen, but there are no subterranean streams, and it would appear that the excavations are complete so far as natural causes are concerned. In regard to the ornamentation, I will simply say that it is superb; no lengthy account can give a clear idea of its grandeur, delicacy, and beauty. Its most curious feature, or rather the one which appeared to me most difficult to explain, is short, irregularly curving, slender projections from certain vertical limestone faces. These are called *Halectites* by the guides. They are but an inch or two long, and project from the rock at various angles. They recall the appearance of icicles formed in a strong wind. The only vegetation noticed were the mycelia of fungi, very delicate, growing on planks used for flooring. I have seen similar ones in many mines.

Page Valley continues southwestwardly from Luray to Port Republic. There are other caverns known in it, among them Wythe's Cave. Hematite and ochre are mined in numerous places, and brick-making is practised on a small scale. The valley broadens out below Port Republic, and, towards Waynesboro Junction, becomes much broken by numerous slate and limestone hills and ridges, some of which attain considerable height, all much inferior in altitude, however, to the Blue Ridge on the east and the sandstone and conglomerate ridges of the Alleghanies on the west. The uneven character of the region causes great turbulence in the streams, numerous beautiful cascades occurring among the hills. The streams have in many places cut for themselves deep and narrow gorges.

The Natural Bridge, reached from Glenwood station on the E. T. V. & Ga. R. R., is over the gorge of Cedar Creek, which is about thirty feet in average width and carries a considerable body of water, flowing into the James River about two miles below the bridge. The magnificent natural arch has a span of about 76 feet at its base; the south wall bulges out somewhat above, so that at a height of fifty feet or so above the creek its width is a few feet greater. The height of the roadway which crosses the arch is about 221 feet above the creek; the thickness of rock at the crest is approximately 41 feet, so that the height of the arch proper is about 188 feet.[1] Its width on top varies from thirty-five to forty feet. The limestones are here bedded very nearly horizontally, just above the bridge dipping only about 5° S. E. Proceeding northwestwardly up the chasm, which maintains its depth for half a mile in this direction, the southern inclination of the beds becomes more pronounced, and at the cataract called Lace Water Falls, 1½ miles up-stream, the dip is 40°–45° S. E.; strike N. 40° E. Below the bridge the creek makes several bends, and the cañon-like character of the gorge is lost. Here the dip is very slightly (5°) N. W., but a quarter mile below becomes again S. E. about 37°, with a strike of N. 70° E. It will be seen that the arch is in a gentle synclinal fold. In *Science*, Jan. 2, 1885, Mr. C. A. Ashburner records his opinion that the Bridge is the remaining top of a cave.

Calcareous tufa is found in considerable quantities along the banks of a little stream which empties into Cedar Creek just below the arch. It incloses shells of mollusks, among them *Helix alternata* and *Physa*, with twigs of Arbor Vitæ (*Thuja occidentalis*), a tree which attains here enormous size—one with a trunk circumference of 14½ feet was measured. This tufa is doubtless of very recent deposition and is, perhaps, even yet accumulating. Between the bridge and the railroad station (2½ miles) there is a broad belt of slate, dipping in general 70°–80° S. E., doubtless geologically overlying these limestones. At the station these are

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[1] Measurements barometrical.

lighter colored than usual and crypto-crystalline in structure; I could find no organic remains in any of these rocks.

The vicinity of Balcony Falls is one of the most interesting localities that it has ever been my privilege to visit. It is diagonally across the valley from the Natural Bridge, on the R. & A. R. R. Here the James River effects its passage through the western quartzite foot hills of the Blue Ridge in a deep, narrow valley. The building of the canal and subsequent construction of the railroad on its tow-path have afforded excellent rock exposures. The most northwestern cut is through white, vitreous, thick bedded quartzite, dipping 60° N. W., with strike N. 53° E. This contains unmistakable borings of *Scolithus*, undistinguishable from the *S. linearis*, of the New York Potsdam. Following the R. & A. R. R. eastward from these exposures, this vitreous quartzite extends about 500 feet, its dip becoming less steep, and is succeeded conformably by some 800 feet of soft, argillaceous, thinly bedded, beautifully laminated and variegated sandstones, much contorted, but at their contact with the quartzite dipping 30° N. W., and so underlying the latter. These tender sandstones contain flakes of white mica. They extend to Balcony Falls station, and are there followed by glassy quartzite again, dipping 50° N. W. The relations of the two at this point I could not satisfactorily determine. Proceeding farther east along the track there again succeeds a thinly bedded, beautifully contorted sandrock series, very greatly resembling the one above described. This has, in general, a very gentle northwestwardly inclination, varying to horizontal, and with local dips in the opposite direction indicating several gentle undulations in the strata. This series is exposed along the line for about 1,000 feet and then succeeded by vitreous quartzite again, which is in the form of an anticlinal and synclinal fold, followed to the east by argillaceous sandstones, again dipping 15° N. W., and so passing under the quartzite. High up in the steep bank the glassy, thick-bedded rock is again seen, occupying its superior position as regards the softer rocks, and dipping about 10° N. W., varying to horizontal, and exposed for about 600 feet. This appears as a detached sheet of rock. Farther east we find it at the level of the track, dipping 65° N. W., and extending thus for about 1,000 feet where there again succeeds a softer, gray, slaty sandrock, the junction being marked by an overhanging ledge of quartzite, with some quartz pebbles; the two series are here, as elsewhere observed, quite conformable, dipping 35° N. W., strike N. 55° E. Much of the softer rock is beautifully banded and variegated. I have little doubt that the glassy quartzite was once a continuous sheet of rock overlying the softer sandstones; this has been broken along at least three lines in the processes of mountain making, and the high abrupt slopes and their regularly succeeding valleys are due to the unequal sub-aerial erosion of the two rock series. About 300 feet from the eastern edge of quartzite above noted, the softer sandstones, here very coarse and containing pebbles of granulite and feldspar, come in contact with the Archæan rocks of the Blue Ridge. These are here unmistakably of the older Archæan, consisting of quartz-syenite and granulite; poorly bedded, but well laminated. The two are widely unconformable. The sandstone conglomerate dips 45° N. W., with strike N. 40° E. The Archæan has dip 65° E.; strike N. 5° E. Professor C. H. Hitchcock has alluded to this contact in Proc. Amer. Inst. Min. Eng., and records his opinion that the Archæan as here exposed is the same as much of that of the Green Mountains. It may be added that these quartz-syenites, etc., are of wide distribution in the Highlands of New Jersey and New York.

The question naturally arises: To what geological epoch are these soft, clayey, variegated sandstones to be referred? The only information I was able to obtain along the section above described is that they conformably underlie the vitreous quartzites, which would appear to be Potsdam, and that they unconformably overlie the older Archæan, and are composed of the materials of its disintegration.

We visited another contact of the Archæan with a basal Silurian rock in Doe River gorge, Eastern Tennessee. The construction of the E. T. & W. N. C. R. R. to the Cranberry Iron Mine has opened this magnificent cañon to travellers. It is several miles in length, and the vertical walls of quartzite rise to heights of 500–700 feet above the turbulent waters of the stream. This quartzite is thickly bedded, and contains many pebbles of quartz and much feldspar in grains of variable size, which is in places abundant enough to make the rock an arkose. At the contact, the Archæan, as exposed on the southern side of the stream along the railroad cutting, is a pegmatite, with no bedding nor lamination, and evidently a segregated mass. The quartzite has strike N. 42° E., and dip 65° N. W. 500 fee teast of this contact the Archæan is a hornblendic gneiss and syenite, much contorted, but dipping on the average about vertically. Near by, these rocks are intersected by an eight-foot trap dyke, composed of very fine-grained, dark-colored rock, weathering with a conspicuous slaty cleavage like that in the Highlands of the Hudson. From this point to Roan Mountain station the trap dykes are numerous, and certain areas of light-colored, massive Archæan rocks are seen; at this station the rocks are, however, again laminated. No well-bedded nor highly micaceous crystalline rocks were seen along this section, and the series may probably be referred to the same age as that of the older Archæan of the New Jersey and New York Highlands.

The Cranberry Iron Mine is located at the eastern end of this railroad, and is inclosed in rocks similar to those above described. It was formerly operated through a long tunnel, but the ore is now obtained in a great open cut 50x100 feet in area and 30 feet in depth. The ore body has been known for many years, and loose surface rock was formerly smelted in an old forge, a mile and a half north of the present excavations; gun barrels were made there during the Rebellion. The bed is of great extent longitudinally, outcropping for several miles, according to statements made by residents of the vicinity. Its thickness at Cranberry is as yet unknown, but is at least 100 feet. Work was begun in earnest about three years ago when the E. T. & W. N. C. R. R. was constructed to afford cheap and convenient transportation for the ore. Under the charge of Mr. Lumsden, a neat mining town has been built up and the enterprise appears prosperous. The ore is peculiar in being self-fluxing; no limestone is used in the furnace at Cranberry, which makes about 7½ tons of pig iron per day, using 15 tons of ore. Formerly, blue limestone was brought in from Elizabethtown, but it was found that better iron was obtained without the flux, and the practice was abandoned. This self-fluxing property appears to be the result of the presence of dark-colored pyroxene, which is extremely abundant. The ore proper is a moderately coarse, poorly crystalline magnetite. Some epidote is associated, and insignificant amounts of white quartz and calcite. There are some bands of feldspathic rock. The inclosing strata are granulite and hornblendic granulite. I could find no mica in either ore or rock. Near the open cut a decomposed granulite gave strike N. 30° E., dip 45° N. W. This may not be the direction of the ore body, however, for the strata are much contorted. The rocks are decomposed to a great depth; along the railroad the cuts have exposed the granulites to a depth of 60 feet, and they are rotten to the rails; I was unable to ascertain how deep this decay extends. It appears to be much more extensive than in the similar rocks south of the moraine in New Jersey and Pennsylvania, and is, perhaps, mainly due to the higher annual temperature. Near the mine the railroad has been cut through a great trap dyke. This rock, apparently a diabase, does not weather into the clay yielded by the granulites, but decays in moderately large pieces, some of which are of spheroidal form.

The great decomposition of the rocks noted above greatly obscures the character of the underlying strata. Except along the streams, or in artificial excavations, exposures are rarely found. Almost the whole of Roan Mountain is obscured by the thick mantle of soil, and it is only on and near the summit that outcrops are found. The peak southeast of the hotel, known as Eagle Cliffs, is mainly composed of granulite, some of it hornblendic, bedded with some hornblende rock and intersected by trap dykes. The strata are much twisted and contain some pegmatite segregations. There is locally a small amount of biotite mica, but no schistose structure to the strata. The eastern and northern sides of the summit are more gneissic, and contain some granite segregations, which have been exploited for muscovite mica. They are intersected by dykes of the rock locally known as *Leopardite*, a porphyritic dark-colored eruptive. These strata are lithologically different from those of Eagle Cliffs in containing more mica, and may be newer. No crystalline limestone has been noted in the vicinity.

Following the valley of the French Broad River eastward from Morristown, Tennessee, we cross successively beds of blue limestone and slate, the latter forming low rounded hills covered with an abundant growth of *Pinus inops*, Ait. A few miles east of Newport, the quartzites, similar to those of Doe River gorge, begin, forming bold bluffs. At Warm Springs, N. C. there is said to be limestone, but we did not stop for observations. Farther east along the river there is more quartzite and some slates. Their geological relations were not made out. Then succeed basal Archæan crystalline rocks, apparently not as extensively developed as farther north ; and near Marshall's station begins a well stratified, schistose, heavily micaceous series, with a general northeast strike and variable dip. These contain abundant quartz and granite segregations. The character of the transition from the heavily bedded, basal Archæan rocks to the schistose and gneissic series was not apparent along this section.

About Asheville these well-bedded rocks are gneisses and mica schists. In places the schist is very compact. In the Swannanoa River the gneiss has strike N. 40° E., dip 85° N. W. It is seen at several points along the W. N. C. R. R., from Asheville to Black Mt. station. Here these schistose strata are well exposed in a few places. They contain much garnet, kyanite and white quartz, and some tourmaline. I would call attention to the great lithological similarity between these rocks and those of our "tide water gneiss"—Westchester Co., New York, Philadelphia, etc.—and to the relative position of the two areas to the heavily bedded basal Archæan areas which lie west of them in each case. The mica mines of North Carolina are found in them, and are paralleled by the great amount of mica in our New York series, which Mr. Chamberlin has so extensively collected, and specimens of which he has repeatedly brought before the

Academy. These rocks extend to the top of Mount Mitchell and are bedded with hornblende schist in limited amount.

Eastwardly, this series is succeeded by strata of shining slates, well exposed in the tunnels and cuttings of the railroad.

Remarks were made by DR. JULIEN and the SECRETARY.

April 12, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Eight persons present.

DR. J. J. FRIEDRICH exhibited some fine specimens of oligoclase, albite and beryl from New York Island.

The President read some measurements, comparing the skeleton of the elephant "Jumbo" with that of the mastodon in Ward's Museum at Rochester.

April 19, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Eighteen persons present.

MR. GEORGE F. KUNZ read the following

MINERALOGICAL NOTES.

A. On the hardness of a Brazilian diamond.

Messrs. Tiffany & Co. have, during the past year, been conducting another experiment similar to the one described in the *American Journal of Science*, July, 1885, and before the New York Academy of Sciences, June, 1885. In this instance a piece of hard round bort from Brazil was placed in the machine for cutting, the other cutting diamond being a South African crystal weighing 4½ carets. If used for cutting other diamonds, an equal amount of this bort will always be removed by an equal amount of the other diamond; the great resistance in the polishing really occurring when the stone is put on the wheel. This stone was put on the wheel March 10, 1885, and remained on over 7½ hours each day until November 15, 1885. It was also placed on the wheel another month during February, 1886. The wheel made 2,800 revolutions per minute, and each revolution gave a trifle over 3 feet of travelling surface. The total amount of travelling surface was 170,000 miles, equal to about seven times around the earth. The result of this was the imperfect polishing of one square centimetre of surface. Upon an ordinary diamond at least one hundred times as much effect would have been produced.

B. A fifth mass of meteoric iron from Augusta Co., Va.

This mass of meteoric iron was given to the late Colonel W. B. Baldwin, of Staunton, Augusta County, Virginia, and was found at or near the place where the largest of the three masses from Augusta County, first described by Professor Mallet,[1] was found. Col. Baldwin was under the impression that it was a detached part of the largest mass. Prof. Mallet received it from him at a considerably later date than the large mass, and having chipped and filed a small flat surface, he found, after etching, the Widmanstattan figures, like those on the large mass. A careful examination has satisfied him that this piece of iron has not been in any way artificially detached from any one of the previously discovered masses, though there is no doubt that all the other four meteoric irons from Augusta Co., including the one now described, are portions of a meteorite which probably exploded in mid-air. Its present dimensions are 8.5 cm. by 6.5 cm., 7 cm. at the widest end, and 3 cm. at the smaller end. This, like the other masses, contains ferrous chloride, which, from its solubility in water, has caused much of the mass to exfoliate and crack off, so that this mass is only a nodular remnant of what was formerly a much larger mass. At one end there is a large fragment weighing several hundred grams, that is in part separated by a fissure 4 mm. wide—a result of oxidation. The following analysis of the mass is kindly furnished by Prof. J. W. Mallet.

Iron	90.293
Nickel	8.748
Cobalt	.486
Copper	.016
Tin	.005

[1] Amer. Jour. of Science, 3 Series, Vol. XV., pp. 337–338.

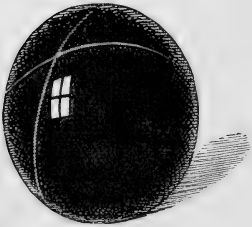
Manganese	trace
Chromium	trace
Phosphorus	.243
Sulphur	.012
Chlorine	trace
Carbon	.177
Silica	.092
	100.072

C. Asteriation in garnet.

M. Babinet examined star garnets, and mentions ("Repertoire d'Optique Moderne") some with four and others with six branches. He says that star garnets with four branches are not rare, he himself having found from twenty to thirty such in from ten to twelve hundred specimens, but that star garnets with six branches are rare, but one of them being found in six thousand specimens. The asteria or star garnets are filled with what he calls filaments or fibres, which cause the asteriated reflections, but he does not state positively what they are. Dr. Isaac Lea ("Proceedings of the Academy of Natural Science," Philadelphia, Feb. 16, 1869) said that in the examination of a thin fractured piece of a large garnet from North Carolina, he was surprised to find minute acicular crystals which took two or three directions. This induced him to examine more closely into the varieties of garnets which were accessible to him. He also examined 154 specimens of Bohemian polished garnets. He found 48 with acicular crystals, and in the precious garnets from Green Creek, Delaware County, Penn., he found, upon examination of uncut crystals, that nearly 25 per cent were possessed of acicular crystals. Some 40 specimens of Brazilian pyrope were very free from spots or cavities, and not an acicular specimen was observed in any one. Essonnite from near Wheeling, Delaware, and spinel from Ceylon were examined, but no microscopic crystals were observed. From the minuteness of these microscopic crystals in the garnet, Dr. Lea says that it would be very difficult to ascertain what they are, but suggests that they may prove to be rutile (Figs. 3, 4, 5, 6, 7, 8 of plate 9, same Proceedings). The figures usually show these crystals arranged in two or three directions, and in Fig 14 two crystals are in part geniculated.

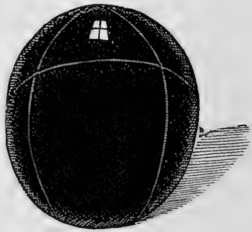
Having examined several hundred carbuncle-shaped Indian garnets, measuring from 12 mm. ($\frac{1}{2}$ inch) to 39 mm. ($1\frac{1}{2}$ inches) in length, the writer found almost the entire lot to be opaque from the immense number of included minerals, especially acicular crystals. Ninety-one crystals in a hundred showed four branches, and nine crystals in a hundred showed six branches. Careful examination in bright sunlight revealed the fact that if the beam of light were allowed to fall near the centre of the dome (see Reflection of Window, Fig. 1) a four-rayed star was observed, but if the light were allowed to fall upon the garnet from the end (see Figure 2), a six-rayed star, or ratner a form resembling two crosses with joined arms, was the result. However, if the centre

FIG. 1.



Natural size.

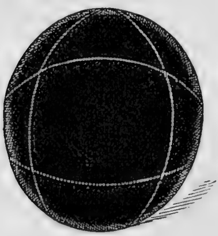
FIG. 2.



Natural size.

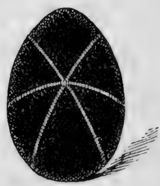
of the garnet were shaded so that a strong light came from each end, an eight-rayed star was the result (see Fig. 3.), showing that the 4, 6, or 8 rays were simply the effect of one or more beams of light condensed by the network of included crystals.

FIG. 3.



Natural size.

FIG. 4.



Natural size.

The occurrence of these crystals in this net- or lattice-work form (see "Transactions" for Dec., p. 76), and the observation that, especially in North Carolina, rutile frequently occurs in quartz and other materials in this same form, although in larger crystals, together with the occurrence of geniculations in garnets from New Mexico, Arizona, and Montana, lead me to the conclusion that these crystals are unmistakably rutile. In each one hundred of the Indian garnets six were as perfect as six-rayed star sapphires (see Fig. 4).

MR. KUNZ also read a note upon

A METEORITE FROM CATORCE, MEXICO.

A mass of meteoric iron, weighing ninety-four pounds, has recently been sent from Catorce, State of San Luis Potosi, Mexico. Mr. Clarence S. Bement, of Philadelphia, who recently secured it, has very kindly furnished me with material for analysis, as well as the facts necessary for its description. He states that the meteorite is an irregular and quite angular mass of iron, showing no oxidation or rounding from wear. It measures thirteen and a half inches in length, eleven inches in height, and seven inches in width. An interesting fact connected with this meteorite is that at the smaller end a seam has been partly opened, and in this is a broken chisel, made of native copper, showing evidently that some aboriginal worker had tried to sever part of this material, but the extreme toughness of the iron had rendered it in this instance impossible. The fact that the chisel is of copper is undoubtedly sufficient proof that it was not put in since the white man settled in Mexico. The mass of meteoric iron found by Professor F. W. Putnam at the altar of mound four, Turner group, of the Little Miami Valley, Ohio, weighs twenty-seven and a quarter ounces, is 9 cm. wide, and 8.5 cm. long. From the second mound of the same group he also procured two small masses, roughly hammered into an ornament, five inches long and three inches wide, having two grooves, which give it the appearance of three fingers. From here, also, were procured several copper ear ornaments, covered with iron, and portions of other ornaments entirely made of iron. From a mound in the Liberty group he procured a celt, made of meteoric iron, 5 inches long, with some ear ornaments. These and the Catorce mass are the only known instances in North America of the aboriginal use of meteoric iron. The Indians of Chili, Bolivia, and Peru, however, made spears, knives, and other ornaments and implements from the masses of meteoric iron that have been found in the Atacama Desert, and the native iron found in Greenland has been worked into knives by the Esquimaux.

MR. B. B. CHAMBERLIN read a paper on the

MINERALS OF STATEN ISLAND.

The lovely island that graces New York harbor is at present assuming new importance, by reason of its connection with contemplated railway enterprises affecting the interest of the metropolis, and it is not improbable that, as this hitherto quiet region awakes from its long repose at the magic touch of commercial enterprise, new opportunities may be afforded for scientific research.

Our English friends have given it the title of the "Isle of Wight of America." It is thought that certain features of scenery justify the comparison.

The geological student may be permitted to suggest additional parallelisms.

Both islands are of an irregular rhomboidal form, each separated from the mainland by narrow channels. Each presents elevated contours of considerable height. The range of downs traversing the English isle finds a resemblance of feature in the gently rounded glacial-drift hills of Staten Island. Mighty geological changes have characterized the history of both islands, and succeeding epochs, with comparatively quiet conditions, have left in each their record of marine deposits.

Sir William Jardine recommended British students in geology to make the Isle of Wight a special field of investigation. American students, especially those of the metropolis, may find it similarly profitable to make our neighboring island worthy of their attention.

The starting-point for an exploration of the island might, with propriety, be the bit of azoic rock outcropping near the Tompkinsville landing. Here the collector may carry away as mementoes of the locality fragments of potash feldspar of the typical structure and color, gray quartz, and, perhaps, fair specimens of muscovite, these constituting an aggregate of coarse granite. The traveller who, at some future day, may take a through train to Baltimore from near this point, will see no further outcroppings of the azoic formation until he reaches the Delaware River.

The hills in front of us, as we look up from the shores of the Narrows, are chiefly serpentine and steatite, which, according to recent investigators, have their origin by metamorphism from the hornblendic schists of the primitive formation. Innumerable broken fragments in our path are of an angular form and of a great variety of tints, in which light-green predominates. It is somewhat unlike the serpentine at Hoboken, and varies very materially from that on New York Island.

This Staten Island rock is occasionally varied by a slaty structure (talcose slate), of a general reddish-brown tint, sometimes showing a variegated aspect, like rare woods for ornamental purposes. This slaty and schistose structure readily passes into a fibrous condition, affording specimens of asbestos, some of which is tough and wood-like, others flexible as flax. The finest variety, known as amianthus, is as soft as silk.

Some of the more interesting minerals here noticeable are marmolite (a foliated serpentine), kerolite, and gurhofite, more solid and compact, and of a creamy-white color, resembling porcelain. The marmolite is often found twisted and twirled in a curious manner.

Among the vein minerals are talc, dolomite, and aragonite, the first-named in laminated masses across the course of the vein. Its colors are white, yellow, and light-green. These tints are often spotted by impurities. Talc is often found in a pulverulent state at the various iron mines. In fineness it surpasses flour; the color is a delicate brown.

The limonite beds of the island may next attract the collector of minerals. These deposits are some half-dozen in number, and have in years past proved of commercial value. At present, the supplies are not as plentiful as heretofore.

The limonite is found in mammillary, botryoidal, and stalactitic forms with highly lustrous surfaces. The most interesting specimens are those with velvet-like surfaces of a beautiful brown color in varying shades.

The most extensive of the mines on the island is that known as the "Richmond," near Port Richmond. In addition to the solid ore here obtained, there existed, years since, extensive deposits of the yellow and red oxides of iron several feet in depth. This earth has been used in the manufacture of paint, but the deposit is nearly exhausted.

Considerable ore has been taken from deposits on Todt Hill, also from a locality near New Dorp, and one or more points near Clifton.

The quartz rock at the various mines is of a highly cellular character, the cavities lined with crystals. The presence of the various iron oxides affords a great variety of tints, the chief of which, the green variety, gives Staten Island a conspicuous place in mineral catalogues. Other colors are yellow, brown, cinnamon, and black. The Richmond mine has afforded handsome specimens of a colorless variety, also of a delicate lavender tint. Prismatic planes are quite unusual among the crystal forms.

This is otherwise with the green quartz at the Todt Hill and Clifton localities, where the crystals are complete, with double terminations, though never of conspicuous size. These are often grouped into handsome specimens and may be also obtained isolated in considerable quantity wherever masses of the cellular quartz are broken into fragments.

The cretaceous formation along the southern section of the island presents features of some interest to the mineralogist.

In the deposits of fire-clay and kaolin may occasionally be found *lignite* and nodules of *pyrite* and *limonite.*

The igneous rocks are represented by the trap dyke along the western portion of the island. This dyke is a continuation of the Palisade range which commences at Ladentown, Rockland County, over fifty miles distant. This ridge is of no great elevation on the island, and is covered by several feet of drift.

The rock is quarried for paving stone. Its yield of minerals is quite limited. The most interesting of these is a greenish albite in finely modified tabular crystals, found at the Port Richmond quarry.

The crystals have a high lustre and are finely striated. They are accompanied by small sections of ice-spar, a purplish mica, and a dark mineral resembling chlorite.

Finally, the mineralogist may keep an observing eye on the drift material, especially that along the eastern and southern coasts of the island. Representatives of the primitive rocks will be found in abundance with an occasional fossil, a wanderer from some far distant locality. The moraines mark the southernmost limit of the great glaciers.

PROF. D. S. MARTIN gave a summary of the geology of Staten Island, and exhibited specimens of its rocks and ores.

PRESIDENT NEWBERRY described some of the geologic features of Staten Island which have an influence upon the sanitary condition of the region.

Remarks were made by Dr. Friedrich and Mr. Kunz.

April 26, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Fourteen persons present.

MR. WILLIAM EARL HIDDEN read a

PRELIMINARY NOTE ON AN IRON METEORITE FROM MAVERICK CO., TEXAS.

This meteorite was found in June, 1882, by C. C. Cusick, of the U. S. Army, on the surface of an old river terrace of the Rio Grande, near Fort Duncan. It possesses characteristics which distinguish it from the famous Cohahuila meteorites. It is rich in schreibersite and troilite.

The mass is 12x10x6 inches, and is oval to a marked degree. Its weight is 97¼ pounds. It has passed into the writer's possession.

MR. HIDDEN said that he had prevented the decomposition of meteorites by using a varnish of collodion containing 5 to 6 per cent of Canada balsam.

MR. B. B. CHAMBERLIN exhibited marcasite from the excavation for the new building of the Metropolitan Art Museum.

DR. A. A. JULIEN read a paper

ON THE VARIATION OF DECOMPOSITION IN IRON PYRITES, ITS CAUSE, AND ITS RELATION TO DENSITY.

(Published in the Annals, Vol. III., No. 12.)

The subject was discussed by the President, Mr. Hidden, and the author.

May 3, 1886.

Regular Business Meeting.

The President, Dr. J. S. Newberry, in the Chair.

Twenty-nine persons present.

Mr. Addison L. Ewing was elected a Resident Member.

The Seal, described and figured as follows, was adopted as the official seal of the Society. The name of the Society, with the date of incorporation, rests upon a background representing the American hemisphere. A lighted Roman lamp surmounts the hemisphere which is surrounded by a dark band, bearing in white letters the motto—"Per maria, per terras."

Dr. J. J. Friedrich exhibited masses of mica schist from excavations in the city, which contain a large amount of magnetite. In the ensuing discussion, statements by Mr. Chamberlin, Dr. Friedrich, and others established the fact of the common occurrence of magnetite in the rocks of New York Island and Westchester Co., disseminated, and in nodules and beds, and associated with muscovite and apatite.

Dr. Britton said that in the "Highlands" of New Jersey and New York the rocks containing magnetite hold less mica, which is mainly biotite. Dr. Elliott thought the apatite in the "Highlands" rocks is more definitely crystalline.

President Newberry said that these facts aid in confirming the belief that the rocks of this locality are certainly Archæan, but of a period later than those of the "Highlands."

MR. W. E. HIDDEN exhibited a polished sphere of quartz $3\frac{1}{12}$ inches in diameter, recently made in Newark, which, in all respects, is equal to the Japanese crystal spheres.

DR. J. S. NEWBERRY delivered an address entitled

REVIEW OF THE FOSSIL FISHES OF NORTH AMERICA, WITH NOTICE OF SOME NEW SPECIES.

(Illustrated with many specimens and drawings.)

(To be published in the Annals.)

May 10, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the Chair.

Fifty-one persons present.

The Secretary, PROF. H. L. FAIRCHILD, read

A HISTORY OF THE SOCIETY,

from its organization in 1817 to the present time.

The topics treated were as follows: Origin—Early Years—Original Members—Officers—Biographical Sketches—Meeting Places—The Lyceum Building—Collections—Library—Publications—The Semi-centennial—Change of Name, etc.

(To be published separately by the author.)

(A number of the old records, including the first minute book, documents, papers, etc., were exhibited.)

May 17, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the Chair.

One hundred and ten persons present.

PROF. C. A. YOUNG read a paper entitled

TEN YEARS' PROGRESS IN ASTRONOMY, 1876–1886.

The Earth.

In what may be called the astronomy of the earth, there is no very great discovery, nothing extremely new and brilliant to record during the past decade; but there has been considerable and steady progress.

a. As regards the earth's form and dimensions, it has become quite certain that Bessel's ellipticity ($\frac{1}{300}$) is too small. Clarke's value of $\frac{1}{294}$ is now admitted and employed on the U. S. Coast Survey with a decided improvement of accordance. A slightly larger value even is suggested by the most recent pendulum observations, and $\frac{1}{292}$ is now adopted in Europe.

One of the most important steps in this branch of investigation is the discovery, by Mr. Pierce (of our own Coast Survey), of the large correction required in many former pendulum determinations, on account of the yielding of the stand from which the pendulum is suspended.

During the past ten or fifteen years, a great amount of material has been collected towards a complete gravitational survey of the earth, by the work of Lieut.-Col. Herschel in India, and of the officers of the Coast Survey in this country and elsewhere, and a very important part of it has consisted in connecting the older work with the new, by Peirce's operations in Europe, and those of Herschel, in this country.

At the same time it has become increasingly evident that very little is now to be gained by endeavoring to find a spheroid fitting the earth's actual form more closely. It will be best simply to adopt some standard (say that of Clarke, but it makes very little difference what), and to investigate hereafter the local deviations from it. These deviations seem to be larger and more extensive than used to be supposed, the station errors in latitude and longitude being at least quantities of the same order as the variations of elevation.

We mention, in passing, the investigations of Fergola, based on observations at Pulkowa and Greenwich, and leading to a suspicion that the axis of the earth is slightly changing its position and shifting the place of the poles on the earth's surface. Operations have been organized to determine the question, by co-operation between different observatories in nearly the same latitude, but widely differing in longitude.

Nor ought we to pass unnoticed an elaborate paper by Kapteyn, of Groningen, on the determination of latitude by a method depending upon time-observation of stars, at equal altitudes, though in widely different parts of the sky; the stars being so selected that all errors of star-places, instrument, and clock, are almost perfectly eliminated. In the same connection we ought to mention also the new equal-altitude instrument, the Almucantar, invented by Chandler, of Cambridge, and his development of the method of determining time by its use. It may possibly supersede the transit instrument for this purpose, as he seems to expect, though we think it hardly likely.

Rapid progress has been made in determining the difference of longitude between all the principal parts of the earth. There now remain very few stations of much importance, which have not their longitude from Greenwich telegraphically settled within a small fraction of a second. In Europe, Albrecht has combined into a consistent whole all the different data for more than one hundred points. Our American system has been similarly worked out by Schott, and is connected with the European by no less than four different and independent cable-determinations. South America is connected with the United States by the recent operations of our naval officers in the West Indies and along the eastern and western coasts of the continent; and with Europe by a cable connection between Lisbon and Pernambuco, also effected by them. It is worth noting that two large errors in European longitudes owe their detection to American astronomers. The difference of longitude between Greenwich and Paris was corrected by our Coast Survey in 1872 to the extent of nearly half a second of time, and our naval officers in 1878 showed that the then received longitude of Lisbon was $8.^s54$ too small! It is a less surprising fact that an error of 35^s was found in the longitude of Rio.

Our navy has also determined an important series of telegraphic longitudes along the eastern coast of Asia and through the East Indies. The French have been doing similar work in the same regions, especially in connection with the transits of Venus; and the English have determined a large number of longitudes in India. These Asiatic longitudes have been recently connected with Australia and New Zealand by English astronomers, and a telegraphic longitude connection has been effected down the eastern coast of Africa from Aden to the Cape ; so that now it is perfectly practicable, if it is desirable, to have one standard of time in all the civilized world.

A word perhaps is here in place as to this question of standard time, and the beginning of the day. The adoption by our railroads of the system of standards differing from Greenwich time only by entire hours has, I think, been admittedly a great step in advance, as regards public convenience and safety in travelling. At a few points, where standard and local time happen to differ by nearly the maximum possible amount of half an hour, some annoyance is felt and there is still some opposition; but it seems quite clear that, in this country at least, all resistance will soon die out.

As regards the more purely astronomical question of making the astronomical day coincide with the civil day, by beginning at midnight, instead of noon, as it does at present, there is more difference of opinion. For my own part, I am frankly in favor of the change, because I see no use in perpetuating an anomaly which is sometimes annoying and confusing. At the same time the change would, of course, involve some inconvenience to computers and night-observers, and it must be admitted that at present a large number, and possibly a majority, of the most eminent astronomers, in other countries as well as in this, are opposed to it. Those of us whose work falls about as much in the day as in the night, and those, I think, who take a long look ahead, are in favor of the reform; but those whose work is mainly nocturnal, or is based on observations made chiefly at or near the "witching hour," dread the inconvenience of a change of date in the midst of the record, and the risk of confusion in the interpretation of old observations.

The question, however, seems to me not a very important one.

I notice that the visitors of the Royal Observatory have just recommended that the change be introduced into the British Nautical Almanac for 1891.

Before passing to the moon, a word should be added as to the outcome of the most recent investigations regarding the steadiness of the earth's rotation. Some irregularities in the lunar motions have appeared to justify a suspicion, at least, that they might be caused by irregularities in the length of the day. The researches of Newcomb upon ancient eclipses and occultations of stars give results not necessarily inconsistent with this hypothesis, perhaps even slightly in its favor; but his careful examination of the past transits of Mercury contra-indicates it pretty decidedly.

The Moon.

During the past ten years there has been no work upon the lunar theory quite on a level with that of Hansen, Delaunay, Plantamour, and Adams in the years preceding; but the labors of Neison, Hill, and Newcomb well deserve mention. The former especially has carried his approximations to a considerably higher point than any of his predecessors, though not without making a few numerical mistakes, which have been detected and corrected by Hill. The investigation of ancient and mediæval observations of the moon by Newcomb is also a very important work, as showing clearly that the lunar theory is still incomplete, and that it is impossible by any tables yet made to represent accurately the whole series of observations. A value of the secular acceleration, which suits the observations of the last two hundred years, will not fit the Arabian observations made one thousand years ago, nor will it satisfy the eclipse observations of still more ancient date; unless at least the received interpretation of those ancient eclipses be admitted to be wrong, as Prof. Newcomb seems to consider rather probable. From his discussion he derives for the secular acceleration a value of 8″.4 as against the value of 12″.1 deduced by Hansen.

It will be remembered probably by every one present that the *theoretical* value of this quantity is about 6″, and that Ferrel, Adams, Delaunay, and others attributed its apparent increase to 12″ to the action of the tides in retarding the earth's rotation and so lengthening the day; if Newcomb's value is correct, this tidal retardation is cut down from 6″ to about to 2″.5.

The study of the moon's surface has been carried on with assiduity, but I do not know that any remarkable results have been reached, though Klein's observation, in 1877, of what he supposed to be a newly-formed crater (Hyginus N.) excited a good deal of interest and discussion for a number of years; and the most eminent selenographers are still divided in opinion on the question.

The publication by the German Government of Schmidt's great map of the moon, in 1878, unquestionably marks an epoch in selenography; and the photographic work of Pritchard, and the heliometric determination of the moon's physical libration by Hartwig, must not pass unnoticed.

Probably, however, the lunar work which has drawn to itself most attention and interest is the investigation of the moon's heat by Lord Rosse, and Professor Langley.

The earliest observations of the kind date back now forty years, when Melloni, in 1846, first detected the moon's heat by means of the then newly invented thermopile. But the first really scientific *measurements* are only about fifteen years old, due to Lord Rosse, at Parsonstown, and to Marie Davy, at Paris; and they seemed to show that at the time of full moon we receive from our satellite, not merely *reflected* heat, but warmth *radiated* from the moon's surface; as if this surface were raised to a considerable temperature by the long insolation to which it has been exposed during the preceding fortnight. Lord Rosse estimated the probable temperature of this heated rock to be as high as from 300° to 500° F.

But within the past four or five years this conclusion has been called in question. Observations at Parsonstown, of the rapid diminution of radiation during a lunar eclipse, seem to favor the newer view, that the moon's surface, like that of a lofty mountain-top on the earth, never gets very hot, since the absence of air enables the solar heat to escape nearly as fast as it is received.

Professor Langley's recent and still progressing work upon this subject far excels in delicacy and elaborateness anything done before. At first it seemed to show that the temperature of freezing water was never reached even at the hottest parts of the lunar surface ; but the later observations throw some doubt on the legitimacy of this inference. It is found that the radiation from the moon unquestionably contains a considerable percentage of rays which have a wave-length *longer* than any of the heat rays from melting ice ; and this fact has been supposed to make it probable that the moon's surface was colder than the ice. But then, within a few weeks, Professor Langley has found the long-waved rays in the radiation from an *electric arc!* So the question still hangs debatable.

The Sun's Parallax.

I think we may say that, during the past ten years, substantial progress has been made with the problem of the solar parallax. The transit of Venus, in 1882, adds whatever value its results may have, to those obtained eight years before ; but, on the whole, so far as can be judged from the reductions thus far completed and published, it would seem likely that the outcome of the transit observations will be simply to confirm the results obtained by other methods. It may be that the data obtained from the German heliometer measurements will prove more accordant and decisive than those derived from photographs and from the contact observations; there are flying rumors that they will, but it will be necessary to await the official publication for certain knowledge on this point. If they do not, we shall be obliged, hereafter, to relegate transit observations to a secondary rank, as a means of determining the sun's distance. From the various observations of the two transits, different computers have deduced values of the parallax all the way from 8″.6 to 8″.95, corresponding to a distance ranging from 95,000,000 to 91,500,000 miles.

The case is quite different with the heliometer observations of the opposition of Mars, in 1877, made by Mr. Gill, at Ascension Island. These give in a most definite and apparently authoritative manner a value of 8″.783, and are apparently irreconcilable with any value much greater than 8″.81, or less than 8″.75. So far as can be judged from the number, nature, and accordance of the observations, I believe we must accept this as the most trustworthy of the geometrical methods yet employed; though the weight of the result would certainly be increased if it did not depend to such an extent upon the work of a single individual.

The confidence of astronomers in the correctness of this value is greatly fortified by the fact that the most recent and reliable determinations of the velocity of light, made by Michelson and Newcomb, in 1877, 1880, 1881, and 1882, when combined with the Pulkowa constant of aberration determined by Nyrèn from all the data available up to 1882, give a solar parallax accordant with the preceding, almost to the hundredth of a second—8″.794 as against 8″.783. It is true there are possible theoretical objections to the method; as, for instance, that the result may be slightly affected by the motion of the solar system through space. Enough is not known certainly about the constitution of the medium that transmits light through space, to decide all such questions *à priori* and authoritatively; but it is unquestionable that any correction needed on account of such possible causes of error must be very minute.

We believe, therefore, that it is safe to assume pretty confidently, that the solar parallax is about 8″.8 (though probably a trifle less), which makes the sun's mean distance 93,000,000 miles, with an error not likely much to exceed 150,000 miles. A larger value of the parallax (about 8″.85) still holds its ground in the nautical almanacs, and undeniably is nearer the *average* of the results given by *all* the known methods. But none of the other methods seem to us to compete at all in precision with the two whose authority we accept.

The Sun and Meteorology.

The study of the solar surface has been carried on very persistently by Spoerer, in Germany, as well as by others, and a great amount of material has been collected bearing upon the theory and nature of sun-spots, and their periodicity. The extensive series of photographs obtained at Kew, and at Dehra Doon, in India, constitutes almost a continuous record of the solar surface for several years. The relation between this periodicity and terrestrial conditions has been assiduously examined, but on the whole the outcome seems to me to leave this connection as doubtful as it ever was, in most cases at least. While in some parts of the earth it looks as if there were a slight but marked increase of storm and rainfall at the time of sun-spot maximum, the reverse seems to be true in other countries. In South America, Dr. Gould thinks that he has demonstrated a very perceptible effect of the condition of the sun's surface in modifying the strength and direction of the winds; but thus far similar investigations elsewhere show no such result. It will evidently be necessary to wait for a longer and more widely extended collection of statistics to settle the question. We do not even know as yet whether we get more or less than the average heat from the sun during the sun-spot maximum.

But I think it may be set down as certain that the condition of the sun's surface exerts, if perhaps a real, yet only a very slight effect upon our earthly meteorology. With terrestrial magnetism the case is markedly and singularly different, and one of the most interesting problems now pressing for solution is the nature of the connection between solar disturbances and magnetic storms.

Solar Heat.

A great deal of labor has been expended upon the study of the sun's heat during the last decade. The investigations that strike me on the whole as most worthy of mention are those of our own Langley and of the Italian Rosetti, whose early death a few months ago is a great loss to science. Secchi and Ericsson, on the one side, had contended for a solar temperature of some millions of degrees, basing their results on Newton's law of cooling; while on the other, Crova and Violle, from their measures of the solar radiation, reduced according to the so-called law of Dulong and Petit, maintained that the temperature does not much exceed that of many terrestrial furnaces, somewhere from 1,500° to 2,500° C. Rosetti's experiments upon the radiation of the electric arc and other sources of intense heat, showed pretty clearly the inapplicability of Dulong and Petit's law to high temperatures, and indicate a solar temperature not far from 10,000° C., or 18,000° F. But they also make it clear that the limits of uncertainty are still very great.

Professor Langley, by his invention of the bolometer, has been able to investigate separately the amount of energy transmitted to the earth in the solar rays of every possible wave-length, and to determine the effect of our atmosphere in absorbing each kind of ray. He has shown that the older method of investigating this solar radiation, *in a lump* so to speak, gives fallacious results on account of atmospheric absorption; and that the necessary correction compels us to increase our estimate of the sun's energy at least twenty per cent. In my own little book upon the sun, published in 1881, I had set the so-called solar constant at twenty-five calorics per square metre per minute. It is now certain that it must be put at least as high as thirty. Professor Langley's investigations seem also to show another remarkable fact—that we do not receive from the sun any at all of the low-pitched, slowly pulsing waves, such as we get from surfaces at or below the temperature of boiling water. The solar spectrum appears to be cut off abruptly at the lower end; and this cutting off we know cannot have been effected in the earth's atmosphere, because we receive from the moon in considsiderable quantity just this very sort of low-pitched rays. Langley finds them also abundant in the radiation of the electric arc, so that we can hardly suppose them to be *originally* wanting in the solar heat. It now looks as if we must admit that they have been suppressed either in the atmosphere of the sun itself, or in interplanetary space. Another striking conclusion first clearly pointed out by Langley is that, if the sun's atmosphere were removed, its light would be strongly blue.

The Solar Surface and Spots.

As regards the general make-up of the solar surface, I do not think there has been any new fact of extreme importance brought out within ten years. Janssen has, however, carried solar photography to higher excellence than ever attained before, and has obtained plates that show the "granules" and their grouping on a scale previously unknown. He thinks that his plates prove a peculiar constitution of the solar surface, consisting in collections of clearly defined and rounded granules, separated by regions or streaks where they are ill defined and elongated; and he calls the phenomenon the "reseau photospherique," or photospheric network. According to him the "net" remains approximately constant for some minutes at a time, as shown by plates taken in quick succession, but is subject to rapid and enormous changes in periods exceeding a quarter of an hour or so. I find some scepticism among high authorities as to the trustworthiness of his conclusions. There are suggestions that the appearances presented may be due to currents of air in the telescope tube and at the surface of the sensitive plate; but I am disposed to think he is right, for, on several occasions when the seeing has been exceptionally fine, I have observed with my own eyes something quite analogous, in our large telescope at Princeton.

The spots have been carefully studied by several observers, by

Spoerer especially, in a statistical way, and by Vogel, Lohse, Tacchini, and others, as to structure and detail. Spoerer has brought out very clearly the connection between the number and average latitude of the spots. It appears that, speaking broadly, the disturbance which produces the sun-spots begins in two belts on each side of the sun's equator in a latitude of over 30°; these belts or spot-zones then gradually move in towards the equator, the sun-spot maximum occurring when their latitude is about 16°; while the disturbance gradually and finally disappears at a latitude of 8° or 10°, some twelve or fourteen years after its first appearance. But two or three years before this disappearance, a new zone of disturbance shows itself in the same latitude as its predecessor, so that for a while, about the time of sun-spot minimum, there are two well-marked zones of spots on each side of the sun's equator; one pair near the equator, due to the expiring disturbance which began some ten or eleven years ago; the other far from the equator, and due to the newly arising out-burst, which will reach its maximum in three or four years, and then pass away like the former.

There can be no doubt that the phenomenon is a very significant one, but its explanation, like that of the periodicity itself, is still to be found.

Nor is the problem of the spots themselves yet fully solved. Not that there is any reasonable question that they are *hollows* in the solar photosphere; but how they originate, how deep they are, and what are the causes of their darkness, and the condition and temperature of the darkening substance; these are questions to which only uncertain answers can now be given. A long and important series of observations upon the widening of the lines of certain elements in the sun-spot spectra has been made by Mr. Lockyer, and establishes clearly the fact that those lines, of *iron* for instance, which are conspicuously black and wide in the sun-spots, are often just those which do *not* show themselves conspicuously in the prominences; and moreover both in spots and prominences the iron lines that do show themselves are most frequently those which closely coincide with lines in the spectra of other substances. Singularly, also, and so far quite without explanation, it appears according to his observations that at the sun-spot maximum those *iron* lines, which at other times are conspicuous in spot spectra, entirely disappear.

Perhaps I may be allowed to mention here a recent observation of my own upon these spot-spectra: with a high dispersion the darkest part of the spot spectrum is found to be not continuous, but made up of fine lines overlapping or almost touching each other, with here and there a clear space left, like a fine bright line. It means, I think, that the absorbing vapors which darken the interior of the spot are wholly gaseous, and tends to disprove the idea that they are mostly of the nature of smoke or steam. We mention also, in passing, another thing which has been shown by our large instrument at Princeton—that the apparently bulbous, finger-tip-like terminations of the penumbral filaments are often, under the best circumstances of vision, resolved into fine, bright, sharp-pointed hooks which look like the tips of curling flames.

The Solar Spectrum.

In 1877, Dr. Henry Draper, of New York, by a series of most laborious, time-consuming, and expensive researches, discovered the presence of oxygen in the sun, evidenced in his photographs, not by fine dark lines, as in the case of elements previously recognized, but by bright, hazy bands. It is difficult to assign any reason why this gas should behave so peculiarly and so differently from others, and for this reason many high authorities are indisposed to accept the discovery. But the evidence of the photographs seems fairly to outweigh any such purely negative theoretical objections.

Other advances have been made in the study of the spectrum, due mainly to the great improvements in spectroscopic apparatus. Until recently it has not been easy to decide with certainty as to some lines in the spectrum whether they were of solar or telluric origin; the great bands known as A and B for instance. It was only in 1883 that the Russian Egoroff succeeded in proving that these are produced by the oxygen in the earth's atmosphere. In his experiments on a scale previously unknown, the light was transmitted through tubes more than sixty feet in length, closed at the end with transparent plates, and filled with condensed gas.

It was quite early pointed out that the sun's rotation ought to produce a shift in the position of lines in the spectrum according as the light is derived from the advancing or receding edge of the solar disc, and Zollner thought he could perceive it. The earliest *measures*, however, were, I believe, those obtained independently by Vogel and the writer, in 1876. In the great bisulphide of carbon spectroscope of Thollon, the displacement becomes easy of observation; and very recently Cornu, by taking advantage of it, and by an extremely ingenious arrangement for making a small image of the sun to oscillate across the spectroscope slit two or three times a second, has been able to discriminate at a glance between the telluric and solar lines; the former stand firm and fast, while the latter seem to wave back and forth.

In this connection also should be mentioned the great map of the solar spectrum, for which Thollon received the Lalande prize of the French Academy of Sciences last January, and the still more accurate and important map photographed by Professor Rowland, by means of his wonderful diffraction gratings, and now in course of publication. Nor would it be just either to omit the earlier and less accurate maps of Fievez and Vogel, which, when published, were as far in advance of anything before them as they are behind the new ones; nor the maps just made by Professor Smyth, of Edinburgh.

It was in connection with the construction of such a map by Mr. Lockyer, that he was led to his theory of the compound nature of the so-called chemical elements, partly as a result of his comparisons of the spectra of different substances with the solar spectrum, and partly in consequence of considerations drawn from certain phenomena observed in the solar and stellar spectra themselves. His first paper on the subject was read late in 1878. This "working hypothesis," as its author calls it, has met with much discussion, favorable and unfavorable. It unquestionably removes many difficulties, and explains many puzzling phenomena; at the same time there are very serious objections to it, and some of the arguments upon which Mr. Lockyer originally laid much stress have turned out unsound. For instance, he made a great point of the fact that, after all precautions are taken to remove impurities, several elementary substances show in their spectra common lines—"basic lines" he called them—indicating, as he thought, a common component. He found in the solar spectrum about seventy of these "basic lines." Now, under the high dispersion of our newer spectroscopes, these lines, which were single to his instruments, almost without exception dissolve into pairs and triplets, and withdraw their support from his theory.

I suppose that at present the weight of scientific opinion is against him; but for one I do not believe his battle is lost. In view of the law of Dulong and Petit, which establishes a relation between the atomic weight and specific heat of bodies, it seems to be pretty certain that *hydrogen* cannot be the elementary "urstoff" out of which all other elements are made by building up, as he at first seemed disposed to maintain; this element stands apparently on no different footing from the rest. But I see no reason why the elements, as we know them, may not constitute one *class* of bodies by themselves, all built up out of some as yet more elemental substance or substances. The "periodic law" of Mendeljeff suggests such a relation. And our received theories so stumble, hesitate, and falter in their account of many of the simplest phenomena of the solar and stellar atmospheres, that a strong presumption still remains in favor of the new hypothesis. I am not prepared to accept it yet; but certainly not to reject it.

The Chromosphere.

The study of the chromosphere and prominences has been kept up, very systematically and statistically, by Tacchini in Italy, and with less continuity, but still assiduously, by several other observers. I do not know, however, that any new results of much importance have been arrived at. The list of bright lines visible in their spectra has been a good deal enlarged; and Trouvelot thinks he has observed *dark* prominences—objective forms that show, black but active, upon the background of bright scarlet hydrogen in the surrounding chromospheric clouds. It may be that he is right; but so far as I can learn, no other observer of the solar atmosphere has seen anything similar. I certainly have not myself. And I think some of his published observations of velocities of two or three thousand miles a second in the motions of the prominences, as evidenced by the displacement of lines in the spectrum, are still more questionable.

In two or three cases, prominences have been observed since 1876 considerably higher than any known previously. In October, 1878, I myself observed one which attained an elevation of nearly 400,000 miles ($13\frac{1}{2}'$).

Eclipses and the Corona.

The sun's corona has been perhaps more earnestly studied than anything else about the central luminary, especially during the four eclipses which have occurred since 1876. At the eclipse of 1878, in the midst of an epoch of sun-spot quiescence, the corona was found less brilliant than ordinary, and especially deficient in the unknown gas that produces the so-called 1474 line—the line which characterizes the spectrum of the corona, and first demonstrated conclusively its solar origin in 1869. But while the corona at this time was less brilliant than it had been formerly, it was far more extensive. At least it seemed so; for at Pike's Peak and Creston, Langley and Newcomb were able to follow its streamers to a distance of 6° from the sun. It is possible, however, that this extension was only due to the superior transparency of the mountain air.

The Egyptian eclipse of 1882 gave us some interesting results respecting the spectrum of the prominences and the corona. It appears that the light of the corona is especially rich in the ultra-violet, and in the photographs of the spectrum a number of bands are found which have been interpreted, with questionable correctness, I think, as indicating the presence of carbon. The eclipse of 1883 was observed in the Pacific Ocean by French and American parties, but, I think, added very little real information. Professor Hastings made an observation which he believed to establish a peculiar theory proposed by himself, viz., that the corona is merely a diffraction effect produced by the moon's limb, and depending on the non-continuity of phase in long stretches of light-vibrations. With a peculiar apparatus prepared expressly for the purpose, he found that at any moment the 1474 line was visible to a much greater distance from the sun, on the side least deeply covered by the moon, than on the other: as unquestionably would happen if his theory were correct. But the same thing would result from the mere diffusion of light by the air; and, notwithstanding his protests, the French observers who were at the same place, and nearly all others who have discussed the observations, think that this was the true explanation of what he saw. So far as I know, the discussion of the subject which has resulted from his publication has only strengthened the older view—that the corona is a true solar appendage; an intensely luminous but excessively attenuated cloud of mingled gas and fog and dust surrounding the sun, formed and shaped by solar forces.

The diffraction theory has one advantage—that it relieves us from stretching our conceptions as to the possible attenuation of matter to the extent necessary in order to account for the fact that a comet, itself mostly a mere airy nothing, experiences no perceptible retardation in passing through the coronal regions. There can be no question that this has happened several times: the last instance having been the great comet of 1882. But on careful consideration it will be found, I think, that our conceptions will bear the stretching without involving the least absurdity; a single molecule to the cubic foot would answer every necessary condition of the luminous phenomenon observed. And all the rifts and streamers, and all the radiating structure and curved details of form, cry out against the diffraction hypothesis.

The observations of the eclipse of 1885 (observed only by a few amateurs in New Zealand) have not proved important.

At present the most interesting debate upon the subject centres around the attempt of Mr. Huggins (first in 1883) to obtain photographs of the corona in full sunlight. He succeeded in getting a number of plates showing around the sun certain faint and elusive halo forms which certainly look very coronal. Plans were made and have been carried out, for using a similar apparatus on the Riffelberg, in Switzerland, and at the Cape of Good Hope. But so far nothing has been obtained much in advance of Mr. Huggins' own first results. Since September, 1883, until very recently, the air has been full, as every one knows, of a fine haze, probably dust and vapor from Krakatoa, which has greatly interfered with all such operations. It is now fast clearing away, and I for one am somewhat sanguine that a much greater success will be reached next winter at the Cape, and perhaps even in England during the coming summer.

Just about the same time that Huggins was photographing in England, Professor Wright was experimenting in New Haven in a different way: isolating the blue and ultra-violet rays by the use of colored media, stopping out the sun's disc and receiving the image of the coronal regions on a fluorescent screen. He also had obtained what he believed, and still believes, to be a real image of the corona, when the aerial haze intervened to put an end to all such operations; for of course it is evident that whether one operates by this method or by photography, success is possible only under conditions of unusual atmospheric transparency and purity.

I suppose at present the predominant feeling among astronomers is that the case is hopeless. and that Huggins and Wright are mistaken. It may be so. But my own impression is that they are probably correct; although, of course, the matter is still in doubt.

Inferior Planets.

Leaving now the sun, and passing to the planetary system, we come first to the subject of intra-Mercurial planets.

The general opinion among astronomers (in which I fully concur) is that the question has been now fairly decided in the negative, *i. e.*, it is practically certain that within the orbit of Mercury there is no planet of a diameter as large as five hundred miles, probably not one hundred. If such a one existed, it could not have failed to be discovered by the wide-angled photographs taken at the eclipses of 1882 and 1883, to say nothing of the visual observations. Of course, it is well known that at the eclipse of 1878 Professor Watson supposed he had discovered two such bodies, and his extensive experience and his high authority led, for a time, to a pretty general acceptance of his conclusion. I notice that Dr. Ball, even very lately, in his "Study of the Heavens," is still disposed to credit the discovery. But Dr. Peters, by a masterly discussion of the circumstances of the observations themselves, and a comparison with the star maps, has shown that it is almost certain that Watson really saw only the two stars Theta and Zeta Cancri. In the same paper also, Peters examined all the observations of small, dark spots crossing the sun's disc which, up to that date (1879), had been made by Leverrier and others the ground for their belief in "Vulcan;" and he shows that they really afford no sufficient ground for the conclusion. As to Mr. Swift's supposed observation of two objects with large discs "both pointing to the sun," they certainly were not the two seen by Watson, while they were in the region covered by Watson and several other observers. What the precise nature of the mistake or illusion may have been it is perhaps not now possible to discover, but I think no one, unless perhaps Mr. Swift himself, now considers the observation important.

While, however, the question of a "Vulcan" is now pretty definitely settled, it is not at all impossible, or even improbable, that there may be intra-Mercurial asteroids, and that some of them may be picked up as little stars of the sixth magnitude or smaller, by the photographers at the eclipse of next August, or in 1887. The sensitiveness of our present photographic plates is now many times greater than it was even in 1882.

As to the planet Mercury, there is very little to report. It "transited" the sun in May, 1878, and again in November, 1881, and during the transits numerous measures were made of its diameter, giving results substantially in accord with the older values. I have already alluded, in connection with the earth's rotation, to Newcomb's investigation of former transits of this planet as establishing the sensible uniformity of the earth's rotation.

The planet Venus, by her transit in 1882, has attracted much attention, and much interest is felt as to the final outcome of the whole enormous mass of data, photographic and visual. Just how long we shall have to wait for the publication, seems still uncertain. I have already said, however, that probably these transits will never again be considered as important as hitherto.

The most important physical observations upon the planet during the decade seem to be those of Langley, who, during the transit of 1882, observed a peculiar, and so far unexplained, illumination of one point on the edge of the planet's disc, and those of Trouvelot and Denning, who have observed and figured certain surface markings of the planet. I think I may fairly mention also our Princeton observation of the spectrum of the planet's atmosphere during the transit, and our confirmation of Gruithuisen's old observation of a white cap (likely enough an ice-cap), at the edge of the planet's disc,—probably marking the planet's pole, and showing that the planet's equator has no such anomalous inclination of 50° or 60°, as stated in some of the current text-books. This cap has also been observed by Trouvelot and Denning. But this lovely planet is most refractory and unsatisfactory as a telescopic object, apparently enveloped in dense clouds which mostly hide the real surface of the globe, and mock us with a meaningless glare.

We mention in passing, but without indorsement, the speculations of Houzeau, who has attempted to account for some of the older observations of a satellite to Venus, by supposing another smaller sister planet, "Neith," circling around the sun in an orbit a little larger than that of Venus, and from time to time coming into conjunction with it. But the theory is certainly untenable; a planet large enough to show phases, as the hypothetical satellite is said to have done, in the feeble telescopes with which many of the observations were made one hundred years ago or more, would be easily visible to the *naked eye even*. There can be little doubt that all the Venus satellites so far observed are simply *ghosts* due to reflections between the lenses of the telescope, or between the cornea of the eye and the eye lens.

Mars.

But while Venus has gained no moons during the past ten years, Mars has acquired two, and they are both native Americans. There is no need to recount the faithful work of Professor Hall with the then new great telescope at Washington and its brilliant result; brilliant in a scientific sense, that is, for regarded as luminaries, it must be admitted that the Martial satellites, in spite of their formidable names of Phobos and Deimos, do not amount to much. Under the best of circumstances, they are too faint to be seen by any but keen eyes at the end of great telescopes. Small as they are, however, the little creatures punctually pursue the orbits which Hall has computed for them, and, when the planet came to its opposition a few weeks ago, they were found just in their predicted places. They are interesting, too, from the light they throw upon the genesis and evolution of the planetary system, almost compelling the belief that they have come *gradually* into their present relation to the planet. The inner one, Phobos, revolves around the primary in 7h. 39m. which is less than one-third of the planet's day. The theory of "tidal evolution" proposed by Prof. G. H. Darwin in 1878–80, as the result of his investigations upon the necessary mechanical consequence of the tidal reactions between the earth, sun, and moon will account for Phobos, and I know nothing else that will, though, of course, it would be rash to assert that no other account can ever be given.

Much attention has also been paid to the study of the planet's surface. In 1876 we were already in possession of three elaborate maps, by Proctor, Kaiser, and Terby, agreeing in the main as to all the characteristic formations. In 1877, Schiaparelli, of Milan, detected, or thought he did, on the planet's surface a numerous system of "canals"—long, straight channels, some of them more than a thousand miles in length, with a pretty uniform width of fifty or sixty miles; and from his observations he constructed a new map, differing from the older ones somewhat seriously, though still accordant in the most essential features. His nomenclature of the seas and continents derived from ancient geography is certainly a great improvement on that of his predecessors, who had affixed to them the names of their friends and acquaintances among living astronomers. There has been some scepticism as to the reality of these "canals;" but in 1879 and 1881 they were all recovered by Schiaparelli, and several other observers, notably Burton, also made them out. Moreover, Terby finds from drawings in his possession that they had before been seen, though not understood or clearly recognized, by Dawes, Secchi, and other observers. At present, the balance of evidence is certainly in their favor, especially as the observers at Nice report seeing them last spring. I do not think the same can be said in respect to another observation of Schiaparelli's on the same object made in 1881. He then found nearly all of these canals—more than twenty of them—to be *double, i. e.*, in place of a single canal there were two—parallel and two or three hundred miles apart. No one else so far has confirmed this "gemination" of the canals; but the planet does not come to a really favorable opposition again until 1890 and 1892, when probably the question can be settled.

The time of rotation has during the past year been determined with great accuracy by Bakhuyzen, who has corrected some errors of Kaiser and Proctor, and finds it $24^h\ 37^m\ 22.66^s$. In 1876, there still remained some question as to the amount by which the planet is flattened at the poles. The majority of observers had found a difference between equatorial and polar diameters amounting to between $\frac{1}{100}$ and $\frac{1}{30}$, while, on the other hand, a few of the best observers had found it insensible. The writer in 1879 made a very careful determination, and found it $\frac{1}{219}$, a quantity closely agreeing with the theoretical value deduced by Adams as probable from the motion of the newly-discovered satellites.

The Asteroids.

On May 1st, 1876, the number of known asteroids was 163. To-day it stands at 258, 95 of these little bodies having been discovered within the decade, 45 of them by one man, Palisa, of Vienna, while our own Peters is responsible for 20.

None of the new ones are especially remarkable, *i. e.*, some of the older ones are always more so; the most inclined and most eccentric orbits, the longest and the shortest periods, none of them belong to any of the late discoveries. One point is noteworthy, that the more recently discovered bodies are much smaller than the earlier ones. The first 25, discovered between May, 1876, and October, 1878, have an average opposition magnitude of 11.2, while the last 25, discovered since April, 1883, average only 12.2; *i. e.*, the first 25 average about $2\frac{1}{2}$ times as bright as the last. Out of the whole 95, two are of the 9th magnitude (one of them, No. 234, was discovered as recently as August, 1883), 14 are of the 10th, 33 of the 11th, 33 of the 12th, and 13 of the 13th. Of these last 13, 10 have been found within the past two years; and of the 12 others found in the same time, 6 are of the 11th magnitude, and 6 of the 12th.

It is clear that there can remain very few to be discovered as large as the 10th magnitude; but there may be an indefinite number of the smaller sizes.

The Major Planets.

As regards the planet Jupiter, the one interesting feature for the past ten years has been "the great red spot." This is an oval spot, some 30,000 miles in length by 6,000 or 7,000 in width, which first attracted attention in 1878. At first, and for three years, it was very conspicuous, but in 1882 it became rather faint, though still remaining otherwise pretty much unchanged. In 1885 it was partly covered with a central whitish cloud, which threatened to obscure it entirely; but this season the veiling cloud has diminished, and the marking is again as plain as it was in 1882 or 1883. How long it will continue no one can say; nor is there any general and authoritative agreement among astronomers as to its nature and cause.

In connection with observations upon this object, several new determinations have been made of the planet's rotation period, and they all show that, as in the case of the sun, the equatorial markings complete the circuit more rapidly than those in higher latitudes; a white spot near the equator gives 9 h. 50 m. 06 s., as against 9 55 36, for the red spot, which is approximately in latitude 30°.

We must not omit to mention Professor Pickering's new photometric method of observing the eclipses of this planet's satellites. Instead of contenting himself with observing merely the moments of their disappearance and reappearance—an observation not susceptible of much accuracy—he makes a series of rapid comparisons between the brightness of the waning or waxing point of light during the two or three minutes of its change, using as the standard one of the neighboring uneclipsed satellites. From these comparisons he determines the moment when the satellite under eclipse has just half its normal brightness;

and this with a probable error hardly exceeding a single second, while the old-fashioned method gave results doubtful by not less than a quarter of a minute. Cornu and Obrecht have independently introduced the same method at Paris. When we have a complete twelve years' series of such observations, they will give an exceedingly precise determination of the time required by light to traverse the earth's orbit, and so, indirectly, of the solar parallax.

As regards Saturn, there is nothing to report so startling as Jupiter's red spot. A white spot, which appeared in 1877, enabled Hall to make a new determination of the rotation period, which came out 10 h. 14 m. 14 s. This is in substantial accord with an earlier determination of W. Herschel's (10 h. 16 m. 07 s.), but involves a serious correction of the value 10 h. 29 m. 17 s. given in most of the text-books. The error probably came from a servile copying of a slip of pen made by some book compiler, fifty years ago or more, in accidentally writing Herschel's value of the rotation of the inner ring, instead of that of the planet.

Much time has been spent in observations of the rings, and Trouvelot has reported a number of remarkable phenomena, most of which, however, he alone has seen as yet. The most recent micrometric measures have failed to confirm Struve's suspicion that the rings are contracting on the planet. Extensive series of observations have been made upon the satellites by H. Struve, Meyer, and others in Europe, and by Hall in this country. Hall's observations are especially valuable, and the series is now so nearly completed that we may soon hope to have most accurate tables. In the case of Hyperion, there is found a singular instance of a *retrograde* motion of the line of apsides of the orbit, produced by the action of an *outside* body, the effect being due to the near commensurability of the periods of Hyperion and Titan. This most peculiar and paradoxical disturbance first showed itself as an observed fact in Hall's observations; and, soon after, Newcomb gave the mathematical explanation and development. He finds the mass of Titan to be about $\frac{1}{12500}$ that of Saturn. It may be noted, too, that Hall's observations of the motions of Mimas and Enceladus indicate for the rings a mass less than $\frac{1}{10}$ that deduced by Bessel: instead of being $\frac{1}{100}$ as large as the planet, they cannot be more than $\frac{1}{1000}$, and are probably less than $\frac{1}{10000}$.

The satellites of Uranus have also been assiduously observed at Washington, so that at present the Uranian system is probably as accurately determined as the Jovian, perhaps more so. The form of the planet has been shown to be decidedly elliptical (about $\frac{1}{14}$) by observations of Schiaparelli and at Princeton;

and the same observers have detected faint belts upon the disc, which have also been seen at Nice, and by the Henrys in Paris. Many of the observations appear to indicate a very paradoxical fact—that the belts, and consequently the planet's equator, are inclined to the orbits of the satellites at a considerable angle. The mathematical investigations of Tisserand appear to demonstrate that, in the case of a planet perceptibly flattened at the poles, satellites near enough to be free from much solar disturbance must revolve nearly in the plane of the equator; while those more remote, and disturbed more by the sun than by the protuberant equator of the planet, must revolve nearly in the plane of the planet's orbit. Thus the two satellites of Mars, the four satellites of Jupiter, and the seven inner satellites of Saturn, all move nearly in the equatorial plane, while our moon and Japetus move in ecliptical orbits. It is very difficult to believe that the satellites of Uranus, which are certainly not ecliptical and are very near the planet, do not move equatorially. And yet it is unquestionable that most of the observations with sufficiently powerful telescopes (my own among them) do seem to indicate pretty decidedly that the planet's equator is inclined as much as 15° or 20° to the orbit plane of the satellites.

As to Neptune, there is nothing new. One or two old observations of the planet have turned up in the revision of old star catalogues, and Hall, of Washington, has made a careful and accurate determination of the orbit of its one satellite, and of the planet's mass; while Maxwell Hall, of Jamaica, has deduced a very doubtful value of the planet's rotation from certain photometric observations of its brightness.

There has been some hope that a planet beyond Neptune might be found. Guided by certain slight indications of systematic disturbances in the motion of Neptune, Todd made an extended search for it in 1877–8, using the Washington telescope, and hoping to detect it by its disc, but without results. If such a planet exists, it is likely to appear as a star between the 11th or 13th magnitude, and may be picked up any time by the asteroid-hunters. But its slow motion and the fact that our present charts give but few stars below the 11½ magnitude, will render the recognition difficult.

The indications I have spoken of, and certain others first noted in 1880 by Prof. G. Forbes, and depending upon the behavior of certain periodic comets, furnish pretty strong reasons for believing in its existence, though as yet they fall far short of making it certain.

Comets.

During the past ten years we have been favored with an extraordinary number of comets, and while perhaps no single great step has been made, yet it is certain, I think, that our knowledge of these mysterious objects has gained a real and considerable advance.

In 1876, curiously enough, not a single comet appeared; but in 1877 there were 6; in 1878, 3; in 1879, 5; in 1880, 5; in 1881, 8; in 1882, 3; in 1883, 2; in 1884, 3; and in 1885, 6; and so far this year, 3. Forty-four comets in all have been observed during the ten years, six of which were conspicuous objects to the naked eye, and two of them, the great comet of 1881, and the still greater one of 1882, were very remarkable ones.

The first of these will always be memorable as the first comet ever photographed. Dr. Henry Draper photographed both the comet itself and its spectrum; Janssen obtained a picture of the comet, and Huggins of its spectrum.

A number of excellent photographs were obtained of the great comet of 1882, especially by Gill, at the Cape. And it is worth mentioning that in May, 1882, a little comet (not included in the preceding list, because no observations were obtained of it) was caught upon the photographs of the Egyptian eclipse.

Two of the bright comets, Wells' comet of 1881 and the great comet of 1882, approached very close to the sun, and their spectra, as a consequence, became very complex and interesting. A great number of bright lines made their appearance. Sodium was readily and certainly recognized; iron and calcium probably, but not so surely. The evidence as to the nature of the sun's corona, derived from the swift passage of the 1881 comet through the coronal regions, has already been alluded to.

The Pons-Brooks comet of 1883–4 is extremely interesting as presenting the first instance (excepting Halley's comet, of course) of one of the Neptunian family of comets returning to perihelion. There are six of these bodies with periods ranging from sixty-eight to seventy years. Halley's comet, the only large one of the group, has made many returns, and is due in 1910. Pons' comet, first observed in 1812, has now returned; Olbers' comet of 1815 is due in 1889, and the three others, all of them small, in 1919–'20 and '22.

I have spoken of them as Neptunian comets, *i. e.*, their presence in our system is known to be due in some way to this planet. The now generally received theory is that they have had their orbits changed from parabolas into their present state by the disturbing action of Neptune. Mr. Proctor has pointed out certain unquestionable, though, I think, inconclusive, objections to this view, and he proposes, as an alternative, the startling and apparently improbable hypothesis, that they have been *ejected* from the planet at some past time by something like volcanic action.

On the whole, however, the most important work relating to comets has been that of the Russian astronomer, Bredichin. He has brought the mechanical and mathematical portion of the theory of comets' tails to a high degree of perfection; following out the lines laid down by Bessel, but improving and correcting Bessel's formulæ, and determining their constants by a most thorough discussion of all the accurate observations available.

It it hardly possible to doubt any longer that all the facts can be represented on the hypothesis that the tails are composed of minute particles of matter, first driven off by the comet and then repelled by the sun. Bredichin's most interesting result, arrived at in 1878, is that the tails appear to be of three, and only three, distinct types—the long straight streamers which are due to a repulsive acceleration about twelve times as great as the sun's attraction; the second and most ordinary class of broad-curved tails for which the repulsive force ranges between one and two and a half times that of the attraction; and, finally, the short, stubby brushes which are found in a few cases, and correspond to a repulsive force not more than one-fourth the sun's attraction. Supposing, as he does, that the *real* repulsion is the same for each atom, the *apparent* repulsion, or repulsive *acceleration*, would be greater for the lighter atoms and nearly inversely proportional to their molecular weights; and so he concludes that probably tails of the first type are composed of hydrogen, those of the second type of hydro-carbons, like coal gas, and those of the third, of iron and its kindred metals. As to the second type, the spectroscope speaks distinctly in confirmation. Tails of the first and third types are not common, and are usually faint, and since Bredichin's result was announced, there has been no opportunity for spectroscopic verification in their case.

I said his investigations had given a mathematical and mechanical explanation of comets' tails; but the *physical* question as to the nature of the force which causes the observed repulsion, remains unsettled, though I think there is no doubt that general opinion is crystallizing into a settled belief that it is electrical; that the sun is not at the same electric potential as surrounding space, and that, in consequence, semi-conducting masses of pulverulent matter, such as comets seem to be, are subject to powerful electric forces as they approach and recede from the central body. At the same time there are those—Mr. Ranyard, for instance—who forcibly urge that the direct action of the solar *heat* might produce a similar repulsive effect by causing rapid evaporation from the front surface of minute particles, charged with gases and vapors, *frozen* by the cold of outer space.

I ought not to dismiss the subject of comets without at least alluding to the numerous unprecedented and interesting phenomena presented by the great comet of 1882: First, its unquestionable relation to, but distinctness from, its predecessors of 1880, 1843, and 1668, the three belonging to one brotherhood, of common origin, and all following nearly the same path around the sun. I call special attention to this point because Miss Clerke, in her new and admirable "History of Astronomy in the Nineteenth Century" (which I hope every one interested in astronomy will read as soon as may be) has, I think, made a mistake regarding it, assigning to the difference between the computed periods of these comets much too great an importance.

The strange elongation of the nucleus of this comet into a string of luminous pearls; the faint, straight-edged beam of light that enveloped and accompanied the comet for some time; and the several detached wisps of attendant nebulosity that were seen by several observers, are all important and novel items of cometary history.

Meteors.

Time will not allow any full discussion of the progress of meteoric astronomy. It must suffice to say that the whole course of things has been to give increased certainty to our newly acquired knowledge of the connection between meteor-swarms and comets, and to make it more than probable that a meteor-swarm is the result of the disintegration and breaking up of a comet. This seems to be the special lesson of the Bielids, the reappearance of which as a brilliant star shower last November attracted so much attention. In an important paper read before the National Academy of Sciences, last April, Professor Newton pointed out how all the facts connected with the division into two of Biela's comet forty years ago, its subsequent movements and disappearance, and the meteoric showers of 1872, and 1885, and especially the peculiar features of this last shower, all conspire to enforce this doctrine.

I mention, doubtfully, in this same connection the recent supposed discovery by Denning of what are generally alluded to as "long radiants:" systems of meteors, *i. e.*, which for weeks, and even months together, seem nightly to emanate from the same point in the sky. One of these radiants, for instance, the first of half a dozen described by Mr. Denning, is about $1\frac{1}{2}°$ north of β Trianguli, and the shower appears to last from July to November, at the rate of perhaps one or two an hour.

If the fact is *real*, it follows inevitably that, disseminated through all the space in which the earth is moving, and has been moving for several years—not less than 1,000,000,000 miles—there are countless meteoroids moving in parallel lines, and with a velocity so great that the earth's orbital motion of nineteen miles a second is absolutely insignificant as compared with theirs. Their speed must be many hundreds of miles per second. This may be true, but I own I am not ready to accept it yet. The observations indicate directly no extraordinary swiftness. Mr. Proctor, whose mind appears at present to be chiefly occupied by the idea that suns and planets are continually bombarding their neighbors (or at least do so at some stage of their existence), ascribes such meteors to the projectile energies of some of the "great" stars. But there is not time to discuss his notion, and it is hardly necessary until it has begun to receive somewhat more extensive acceptance. I am not aware that so far he has any converts to his theory of comets and meteors.

Stars.

Want of time will also prevent any adequate treatment of the recent progress of Stellar astronomy.

Two great works in the determination of star places must, however, be mentioned. One is the nearly completed catalogue of all the northern stars, down to the ninth magnitude, begun almost twenty years ago, under the auspices of the Astronomische Gesellschaft, by the coöperation of some fifteen different observatories. The observations are now nearly finished, and several of the observatories have already reduced and published their work. A very few years more ought to bring the undertaking to a successful end.

Another similar work, almost, though not quite, as extensive, is the great catalogue of southern stars, made at the observatory of Çordova by our own Dr. Gould and his assistants. He himself, with his own eyes, observed every star of the whole number—nearly 80,000—his assistants reading the circle and making the records: and the whole has been reduced, printed, and published within the space of twelve years—a veritable labor of Hercules, for which, most justly, our National Academy has awarded him the Watson medal. He had already, some years ago, received the gold medal of the English Royal Astronomical Society, for the *Uranometria Argentina*, an enumeration of all the naked-eye stars of the southern hemisphere, with their approximate positions and estimated magnitudes. This, however, was only a sort of preliminary by-play, to pass the time while waiting for the completion of his observatory and meridian circle.

We must mention also the remarkable star-charts made by Dr. Peters, of Hamilton College, of which he has already published and distributed at his own expense about twenty, and more are soon to follow.

But the old-fashioned way of cataloguing and charting the stars is obviously inadequate to the present needs of astronomy, and a new era has begun. While, hereafter, as hitherto, the principal stars, several hundred of them, will be observed even more assiduously and carefully than ever before, with the meridian circle or similar instruments, the photographic plate will supersede the eye for all the rest. It is now easily possible to photograph stars down to the thirteenth or fourteenth magnitude, and to cover a space of $2\frac{1}{2}°$ square on a single plate. The remarkable thirteen and one-half inch instrument constructed by the Henry Brothers, for the Paris observatory, and first brought into use last August, does this perfectly. Instruments very similar, but smaller, lately set up at Harvard College, at the Cape of Good Hope, and at Liverpool, while they do not reach so faint stars, cover more ground at a time.

Negotiations are already under way to secure the co-operation of a number of observatories for a photographic survey of the heavens; and it is probable that, after some preliminary consultation and before very long, it will be actually in progress. According to Struve's estimates, it could be accomplished in about ten or twelve years, even on the Paris scale, by the combined efforts of fourteen or fifteen establishments. Orders have already been given to the Henry Brothers, by Dom Pedro, of Brazil, and Mr. Common, of England, for instruments precisely like the one at Paris. Americans, and New Yorkers especially, may well take a peculiar interest in Astronomical photography, since it was at Cambridge, in 1861, that the first star-photographs were ever made, and here in New York, Rutherfurd and Draper were among the earliest and most successful workers: in the observatory above us is now mounted the very instrument with which Rutherfurd made his unrivalled pictures of the moon and his plates of the Pleiades, more than twenty years ago.

During the past ten years, stellar photometry has become almost a new science. Its foundations, indeed, were laid by J. Herschel, Seidel, Wolff, and Zöllner, before 1870, and the magnitudes of some two hundred stars had been measured, and the law of atmospheric absorption determined. But the great work of Pickering, at Harvard, in the invention and perfecting of new instruments, and his Harvard photometry, which gives us a careful measurement of the brightness of all the naked-eye stars of the northern hemisphere, marks an epoch. And he is pushing on, and has already well under way the measurement of the 300,000 stars of Argelander's Durchmusterung. Nor must we omit to mention Pritchard, of England, whose name has just been joined with Pickering's by the Royal Astronomical Society, in the bestowal of their gold medal for his wedge-photometer and the photometric work done with it. The Harvard photometry, and the Uranometria Oxoniensis together will carry down to all time the record of the present brightness of the stars. They will be especially valuable as data for determining changes in stellar brilliancy.

During the past ten years the number of variable stars has risen from about 100 to nearly 150; and our knowledge of their periods and light-curves has been greatly improved. In America, Chandler and Sawyer, of Boston, and Parkhurst, of this city, have done especially faithful work. During the ten years we have had two remarkable "temporary stars," as they are called—first the one which, in November, 1876, in the constellation of Cygnus, blazed up from the ninth magnitude to the second and then slowly faded back to its former brightness, but to a *nebulous* condition, as shown by its spectrum. Then also the one which, last autumn, appeared in the heart of the nebula of Andromeda as of the sixth magnitude (where no star had ever been seen before), slowly dwindled away, and is now beyond the reach of any existing telescope. Perhaps, too, we ought to mention another little ninth magnitude star in Orion's club, which last December rose to the sixth magnitude, and is now fading; it seems likely, however, from its spectrum, that this is only a new variable of long period.

As to star-spectra, a good deal of work has been done in their investigation with the ordinary stellar spectroscopes by the Greenwich Observatories, by Vogel at Potsdam, and by a number of other observers,—work well deserving extended notice if time permitted. But the application of photography to their study, first by Henry Draper in this city, and by Huggins in England, is the important new step. By the liberality of Mrs. Draper, and as a memorial of her husband, his work is to be carried on with the new photographic instrument and method just introduced by Prof. Pickering at Cambridge. He is able to obtain on a single plate the spectra of all the stars down to the eighth magnitude in the group of the Hyades, each spectrum showing under the microscope the characteristic lines quite sufficiently for classification. A different instrument is also to be built with the Draper fund, which will give single star-spectra on a much larger scale and in fuller detail.

During the decade, the stellar parallax has been worked at by a number of observers. Old results have been confirmed or corrected, and the number of stars whose parallax is fairly determined has been more than doubled. The work of Brunnow and Ball in Ireland, of Gill and Elkins at the Cape of Good Hope, and of Hall at Washington, deserves especial mention. A new heliometer of seven inches aperture has been ordered for the Cape observatory, and when it is received, a vigorous attack is planned by co-operation between that observatory and that of Yale College, which possesses the only heliometer in America.

During the ten years, our knowledge of double stars has been greatly extended; several observers, and most eminent among them Burnham, of Chicago, have spent much time as hunters of these objects, and have bagged between one and two thousand of them. Several others, especially Doberck in England, and Flammarion in France, have devoted attention to the calculation of the orbits of the binaries, so that we have now probably about seventy-five fairly well defined.

In the study of the nebulæ, less has been done. Stephan at Marseilles and Swift at Rochester have discovered many new ones, mostly faint, and Dreyer, of Dublin, has published a supplementary catalogue, which brings Sir J. Herschel's invaluable catalogue pretty well down to date. The studies of Holden upon the great Orion nebula and the so-called "trifid nebula" deserve special mention, as securely establishing the fact that these objects are by no means changeless, even for so short a time as twenty or thirty years; also the discovery of a new nebula in the Pleiades by means of photography.

Observatories.

During the ten years, a considerable number of new observatories have been founded. Abroad we mention as most important the observatories for astronomical physics at Potsdam, in Prussia, and at Meudon, in France, also the Bischoffsheim observatory at Nice and its succursal in Algiers. The great observatory at Strassburg can hardly be said to have been founded within the period indicated, but the new buildings and new instruments and new efficiency date since 1880. We ought not to pass unnoticed the smaller observatory at Natal, in South Africa, and the private establishments of von Konkoly at O-Gyalla, of Gothard at Hereny (both in Hungary), and of the unpronounceable gentleman Jedrzejewicz at Plonsk, in Poland, and the observatory at Mount Ætna, from which, however, we have no results as yet.

In the United States we have the public observatories at Madison, Wis., at Rochester, N. Y., and at the University of Virginia, and the, as yet, unfinished Lick Observatory in California: also a host of minor observatories connected with institutions of learning, and mainly designed for purposes of instruction; such establishments have been founded within ten years at Princeton, at Northfield, Minn., at South Hadley, Ms., at Beloit, at Marietta, at Depauw, at Nashville, and at St. Louis, also at Franklin and Marshall College, and at Doane College, in Nebraska; at Columbia College, Ann Arbor and Madison, Wis., and at one or two other institutions which escape me for the moment. Several others are also at this moment in process of erection. Every one of them has a telescope from six to thirteen inches aperture, with accessory apparatus sufficient, in the hands of an astronomer, for useful scientific work.

Instruments.

A large number of new instruments of great power have been constructed. We mention the great thirty-inch refractor of Pulkowa, the twenty-six-inch of Charlottesville, and the twenty-three-inch at Princeton, for all which the lenses were made by our own Clark. We add the great Vienna twenty-seven-inch telescope by Grubb, and the twenty-nine-inch object glass by the Henrys, made for the Nice observatory but not yet mounted; also the nineteen-inch telescope at Strassburg by Merz. Grubb has also at present a twenty-eight-inch object glass under way for the Greenwich observatory, and Clark has nearly completed the monstrous thirty-six-inch lens for the Lick observatory. There never was a decade before when such an advance in optical power has been made.

Great *reflectors* have been scarce, the only ones of much importance constructed during the time being the twenty-inch instrument at Algiers, and Mr. Common's exquisite three-foot telescope, which he has lately sold to Mr. Crossley in order to make way for one of five-feet diameter now, I believe, under construction. The old three-feet and six-feet instruments of Lord Rosse have been improved in various ways, and are still in use—especially in work upon lunar heat. Among newly *invented* instruments we mention the meridian photometer of Pickering, the wedge photometer of Pritchard, the almucantar of Chandler, the concave diffraction grating of Rowland, and the bolometer of Langley—all but one American. Repsold's improvements in the micrometer, in the heliometer, and in the mounting of equatorials should also be mentioned here.

As to new astronomical methods, enough has been already said about photometry and astronomical photography. It is plain that we are entering upon a new era.

Literature.

Astronomical literature has flourished. Among the books of the last ten years, important in one way or another, I mention in the first rank the great work of Oppolzer upon orbit calculation, Gylden's "Astronomy," and the papers of Tisserand, Neison, Darwin, Adams, Hall, and Newcomb, on numerous subjects. Among the popular books on general astronomy, we have Newcomb's "Popular Astronomy," Ball's "Story of the Heavens," Kaiser's "Sterrenhemel," Fayes' "Origine de la Monde," and Miss Clerke's admirable "History of Astronomy in the Nineteenth Century." More special popular treatises are Nasmyth's and Neison's books upon the moon, Lockyer's "Solar Physics," and my own little book upon the sun, Ledger's "Sun, Moon, and Planets," Gledhill's and Flammarion's books on double and binary stars, and Terby's "Areographie." Of course, it is possible to mention only a few, and I name those which, in one way or another, have attracted for some reason my special attention, leaving doubtless many others just as valuable unreferred to.

A few new astronomical periodicals have sprung up. In England, *The Observatory* was founded in 1877, and has become an established and very valuable publication.

Copernicus was a still more important and elevated journal, but did not appeal to so large a circle of readers, and, I am sorry to say, died only three years old.

In France, the *Bulletin de l'Astronomie*, recently established, is extremely valuable, and I trust will be able to maintain itself. Less importance attaches to Flammarion's *L'Astronomie*, which, however, I presume, has many more readers. *Ciel et Terre* is a new astronomical magazine published at Brussels.

In the United States, we have but one distinctively astronomical journal, the *Sidereal Messenger*, published by the energetic young director of the Carleton College Observatory in Minnesota. It is interesting and, in many ways, excellent, but in some respects not yet quite up to the standard of American astronomy. There is room and need among us for an astronomical journal of high mathematical character; but its financial success would be questionable.

Necrology.

The ten years have stricken from the roll of astronomers a few illustrious names, and many of honorable rank. Leverrier, the greatest of them all, died in 1877, and Secchi in 1878; Lamont and Maclear in 1879; Peters, the veteran editor of the *Astronomische Nachrichten*, Lassel, Dembowski, Peirce, and Watson were taken in 1880. Bruhns died in 1881. In 1882, we lost Zoellner, Plantamour, Challis, and Henry Draper. Villarceau died in 1883, Klinkerfues and Schmidt in 1884, and last year Webb, the author of that *vade mecum* of all amateur astronomers, the "Celestial Objects for Common Telescopes."

It would probably be invidious and unwise to attempt to designate precisely those of our younger astronomers who are to succeed to the eminence of those we have lost. It will be easier to prophesy after the fact. But one cannot go wrong in saying that among the astronomical names which have either first appeared, or have first become conspicuous, during the past decade, we ought to mention, in our own country, Pickering, Holden, Langley, Stone, Burnham, Boss, Chandler, Pritchett, Todd, Paul, Payne, and Elkin. In Europe, we have Gill, Darwin, Common, Gledhill, Tisserand, Vogel, Palisa, Hasselberg, H. and L. Struve, Hartwig, Valentine, and Von Konkoly. And there are many others, both here and abroad, hardly, if at all, their inferiors.

In this rapid, though, I fear, tedious review, I have tried to put before you a just and fairly proportioned sketch of the progress that has actually been made. While no great discovery like that of gravitation appears upon the record, yet I am inclined to think that, with one or two exceptions (during the life of Galileo and Newton), no other decade in all the history of our unselfish science can make a better showing.

As an American, too, I have been surprised and delighted to find how honorable a place our American astronomers hold in the record. Take out of the ten years' story the works of Hall and Newcomb and Gould, of Draper, Langley, and Pickering, of Burnham, and Holden, and Stone, and the loss would indeed be grievous.

May 24, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Thirty persons present.

The following resolution was presented by PROF. D. S. MARTIN, and adopted:

Resolved, That this Society expresses its sense of the great value and importance of the work done by the National Board of Health, and believes it to be highly desirable that Congress should enact such legislation as will give efficiency to the Board, and should provide appropriations for use under its direction, as in former years.

DR. STEPHEN SMITH read a paper entitled

THE SUBJECT OF THE SANITARY INFLUENCE OF VEGETATION IN CITIES, AND THE IMPORTANCE OF TREE-PLANTING TO THE HEALTH, BEAUTY, AND SUMMER TEMPERATURE OF NEW YORK, WITH PRACTICAL SUGGESTIONS IN RELATION THERETO.

PROF. D. S. MARTIN expressed his especial interest and pleasure in the paper of Dr. Smith. He had long been convinced that the greatest defect of New York was its treelessness. Its position should render it a cool city, lying directly on the sea and harbor, and with rivers on either side; but these remarkable advantages are largely counteracted by the fearful heating of its miles of shadeless pavement and wall. Of course, the sun-heat absorbed during the day must be radiated into the air at night; and hence the coolness felt in the country soon after sunset does not come to the relief of New York until half the night is past. After speaking of the several ways in which trees and vegetation tend to modify heat, Prof. Martin expressed the hope that some steps might be taken, as a result of this paper, to arouse public sentiment, and enlist public spirit in the direction of tree-planting in the metropolis, as the greatest material need, both sanitary and æsthetic, of our otherwise noble and beautiful city.

The subject was further discussed, in a similar strain, by DR. JULIEN and the PRESIDENT.

May 31, 1886.

STATED MEETING.

The President, DR. J. S. NEWBERRY, in the chair.

Twenty-five persons present.

MR. B. B. CHAMBERLIN exhibited a specimen of actinolite from a bed of hornblendic gneiss at 135th street and Harlem River. The flat, rhombohedral prisms are in radiated groups, with good terminations, and often from three to five inches in length. They are of a deep olive-green color, and quite equal to those from more celebrated localities. The associated minerals are rutile and sphene.

TRANSACTIONS NEW YORK ACADEMY OF SCIENCES, MAY, 1886.

ALMANDINE GARNET CRYSTAL.

ACTUAL SIZE.

Found in New York City, November, 1885. Weight $9\frac{2}{3}$ pounds (4.4 Kilogr.).

Collection of G. F. Kunz.

Dr. E. S. F. Arnold exhibited a cluster of flattened crystals of quartz from the Hot Springs of Arkansas.

Mr. George F. Kunz presented the following description and illustration of the large garnet which was exhibited at the meeting of December 7, 1885.

The finest large garnet crystal ever found, perhaps, in the United States, was discovered, strange though it may seem, in the midst of the solidly-built portion of New York City. It was brought to light by a laborer excavating for a sewer in West 35th Street, between Broadway and Seventh Avenue, in August, 1885. A quartzite vein, traversing the gneiss, contained the crystal. The laborer took it to Mr. J. J. King, from whom I received it.

The accompanying plate, engraved by our fellow-member and mineralogist, Mr. B. B. Chamberlin, is a faithful representation of this interesting garnet.

In form the crystal is a combination of the 2–2 tetragonal trisoctahedron (trapezohedron), the predominating form, and I–dodecahedron, and 3–$\frac{3}{2}$ hexoctahedron.

It weighs nine pounds ten ounces (4.4 kilos), and measures fifteen cm. (six inches) in its greatest diameter, and six cm. on its largest trapezohedral face.

Twenty of the trapezohedral faces of the crystal are perfect, while the remaining faces were obliterated in the formation of the crystal by pressure against the quartzite matrix.

On the surface the color is a reddish-brown, with an occasional small patch of what is apparently chlorite, which greatly enhances its beauty. On a fractured surface, however, the color is a light almandine, and the material in the interior of the crystal is found to be very compact.

This "find" is of peculiar interest, because within the past few years large garnets have been brought to light at other localities in this country, notably at Salides, Col.,[1] where large almandine crystals occur, which are very perfect, and are coated with a chloritic schist, readily removed by an acid, leaving the garnet with clean surfaces, though not smooth. Crystals weighing from five to ten pounds, and one weighing fourteen pounds, have come to the writer's notice. They are in a chloritic schist which

[1] Vol. xxxiv., A. A. A. S., 1885, meeting, p. 241.

is so soft that they can be taken out unbroken. In form they are almost without exception rhombic dodecahedrons, I–.

In Burke County, N. C.,[1] near Morganton and Warlick, where garnets are mined for emery purposes, they are found in sufficient quantities to warrant the establishment of grinding-mills.

They are usually coated with a hydrous oxide of iron from a superficial decomposition, but are sometimes compact enough internally to be cut into slabs several inches in size, or even into small dishes. Some of these crystals which have come into my possession weighed twelve pounds. A few weighing eighteen pounds have been found. They are usually quite perfect on every face, the trapezohedron 2–2 being the common face.

Although both of the above localities have afforded larger crystals, yet no finer crystal of its size than the one here illustrated has ever come under the writer's notice. The finding of an single isolated crystal is not singular, as garnet and tourmaline are often so found.

Mr. Kunz also exhibited some pseudomorphs of quartz after minerals in mica. The quartz contained relatively large cavities holding water.

The method of formation in siliceous minerals of such cavities with water was discussed by the President.

Prof. D. S. Martin spoke of the remarkable character of New York Island as a mineral locality, and the desirability of a permanent exhibition of its minerals. It was agreed, after discussion, that some concerted action should be taken to gather and preserve a representative collection before buildings so cover the island as to render collection impossible. The American Museum of Natural History was suggested as the proper place of deposit, and the collection of Mr. Chamberlin as a good nucleus, it now being the finest collection of New York minerals in existence.

Mr. George F. Kunz read the following paper:

[1] American Gems, in "Mineral Resources of U. S.," Wash., 1883–'84, page 746.

ON ROCK CRYSTAL; ITS CUTTING IN JAPAN, GERMANY, AND THE UNITED STATES.

(Illustrated with crystal spheres and other objects of transparent quartz, including some of the largest pieces in the country.)

Pliny, Seneca, and many other ancient writers, as well as the early fathers of the church—Austin, Gregory, Jerome, etc.—firmly believed that rock-crystal was but water congealed by a cold so intense that ordinary methods could not melt it. Pieces of rock-crystal were undoubtedly used by the ancients for burning-glasses, and Pliny says: "I find it asserted that, when any part of the body requires to be cauterized, it cannot be better done than by means of a crystal ball held up against the sun's rays."

Orpheus recommends the employment of the crystal ball to kindle the sacrificial fires, adding that, though a kindler of flame, the ball, strange to say, is icy cold when snatched from the midst of the fire.

Pliny mentions a crystal trulla which was purchased by a lady of his time for $1,500; and the story of Nero's breaking two cups engraved with subjects taken from Homer, when he was informed of his deposition by the Senate, is familiar to all.

A mass of crystal weighing fifty pounds was dedicated in the capitol by Livia, the empress. Mention is also made of a crystal bowl with a capacity of four sextarii, or two quarts.

Sir Thomas Brown, in his famous "Vulgar Errors," published in 1646, says that crystal is nothing else but snow or ice concreted, and by time congealed beyond liquation—the Greek word krystallos meaning ice.

Crystal balls are not of Japanese origin only, as is commonly supposed, but have played an important part in the occult sciences of various nations, and were extensively used by soothsayers and other wonder-workers in their time. Matter relating to this use of crystal may be found in "State Papers Dom. Elizabeth," A.D. 1590, vol. 233, No. 72.

Spherical objects of crystal and stone have been repeatedly found with remains of the Saxon period, which may be regarded as amulets or connected with divination.

An interesting account of the finding of such relics of the conjuror's art in the ancient graves of Warwickshire is given in the *Archæological Journal,* vol. IX., p. 336–338. And further description is contained in *Archæologia,* vol. XXXIV., p. 46.

In its smaller forms, pure quartz is held by the Japanese to be the congealed breath of the White Dragon; and in its larger and purer forms, they hold it to be the saliva of the Violet Dragon. The belief of the ancients, both Orientals and Occidentals, was that quartz-crystal was nothing but pure water congealed by intense cold, and found only in the regions of eternal frost, hence the name of rock-crystal was *clear ice*, and the one word served alike for the stone and for ice. The Chinese and Japanese word "suisho" reflects a similiar idea, meaning "substance of water," and the theory of its production was part of the pagan conception of the universe. Of the nine kinds of dragons in the pagan world of imagination, several have much to do with the preservation of the hidden treasures of the earth and the deep. They guard these jealously, and diver and miner ever run the risk of exciting their anger.

Sir Thomas Brown in his "Hydrotaphia, or Urne Burial," chapter II., p. 9, notices a Roman urn preserved by Cardinal Farnese, in which were found a crystal ball and six nuts of crystal, three glasses and two spoons, besides a great number of gems engraved with heads of gods and goddesses, an ape in agate, and a grasshopper and an elephant of amber. Two other urns which were discovered had "a kind of opale in each, one yet maintaining a bluish color. Some of these trinkets were doubtless the dearest treasures of the deceased, in which they took great delight when living, and were deposited with their ashes by friends for use in the other world; or, perhaps, the desire to remove from sight everything that, from its associations with the departed, could awaken grief may have prompted this action in some cases."

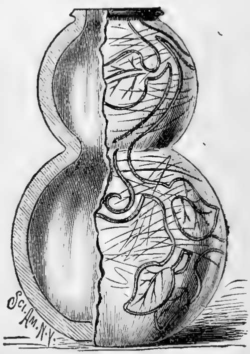
In the "Museum Brittanicum, being an exhibition of a great variety of antiquities and natural curiosities belonging to that noble and magnificent collection, the British Museum, illustrated with curious prints and explanations of each figure, by John and Andrew Van Rymsdyck, Folio, London, 1778," we find curious illustrations of our subject. Plate XVIII., Fig. 5, page 46, is thus explained: "A round christal ball, exceedingly brilliant, very often found in sepulchres—likewise an amulet." . . . "Are often found in sepulchres with a variety of other gems, etc., which they left with the dead as guardians of the manes." Montfaucon ("Monumens de la Monarchie Française," vol. I., p. 15) mentions the finding of a globe of crystal in the monument of Childerick, and adds that in another sepulchre no less than twenty balls of crystal were found. There are two hundred and sixty-six pieces of rock-crystal in the Green Vaults at Dresden, many of which were numbered among the treasures of the Vaults and the Chamber of Art, before 1640. A large part of the present collection was purchased by August the Strong, in Italy, and cut by the renowned worker in crystal, G.

B. Metellino, of Milan. The material came originally from Switzerland, Savoy, and Hungary, some, however, being contributed by the Emperors of Austria.

One of the finest known works in rock-crystal is an urn 9½ inches in diameter and 9 inches high, which, together with its foot or pedestal, is formed of one piece of material. On the upper part of this urn there is a representation of Noah asleep, his children holding a covering over him, and a woman, with a basket of fruit in her hand, standing near. The cost of this remarkable work of art was £4,000.

The chief source of this supply of rock-crystal was the Alps, where it is found, not only in pockets, but also in the moraines of the glaciers.

The largest and most perfect ball of crystal known is in the Dresden Green Vaults (No. 174 Preziosensaal); it weighs 15 German lbs. and is 17 cm. in diameter. In olden times, it was probably used by masters of the occult sciences in prophecying and wonder-working.



Double-bulb vial of rock crystal penetrated by acicular crystals of hornblende.

The famous clock in the form of the Tower of Babel, made by Hans Schlotheim, a clock-maker of Augsburg, contains a crystal ball which plays a very important part in its diurnal labor. Every minute this ball comes out on the top of the clock by means of ingenious mechanism and, running down around the tower, falls in below, where, rebounding from a lever, it retraces its course.

Crystal balls were used, nearly a century ago, for the feet of pianos, and were also employed by the ladies of the period for cooling the hands. The Italians of the present day use them for the same purpose.

Crystal vials are manufactured so cheaply that one, 2 inches in height, forming two hollow spheres, placed on the other and both hollowed out from one end, the perforation leading to each ball not being over one-fourth of an inch in diameter, was sold for $11, although it was beautifully penetrated with acicular crystals of hornblende.

Crystal bottles have been sold to fashionable people here for many years, and, as is often the case with articles of American taste and ingenuity, bottles, not only finer in form, but also of a workmanship and carving much superior to any that have been brought from Japan, have found a ready sale at from four to five times the prices of Japanese bottles of the same size.

The only rock-crystal object in the United States for which a piece of crystal of the largest size was required is a round disk, $9\frac{7}{8}$ inches in diameter, on which is cut, in intaglio, the episode of

Japanese method of grinding and polishing crystal balls.

Moses in the bulrushes. This rare specimen is in the possession Tiffany & Co., and is exhibited here this evening. This remarkable piece was unfortunately dropped by the engraver after completion, and is now in two pieces; but this mutilation does not prevent us from realizing what a fine specimen of rock-crystal it was originally.

The Japanese methods of working crystal are very simple. Skill, patience, and hereditary pride make up for any lack of labor-saving tools, for there the workman can often trace back his pedigree, in unbroken line, to twenty generations. The crystal is first roughly dressed into proper pieces for forming crystal balls or other objects. If the piece is too long to be formed into a ball, it is broken into several pieces. If it is a large compact mass, it is only chipped on the edges. In order to break large, thick crystals, a nick is often hammered round them, and then a sharp, well-directed blow will make a clean break. The masses, whether large or small, are gradually rounded by careful chipping with a small steel hammer, this rude tool alone sufficing to make a perfect sphere. The workmen thoroughly understand the fracturing of the crystals and apply either chipping or hammering, as the case may require.

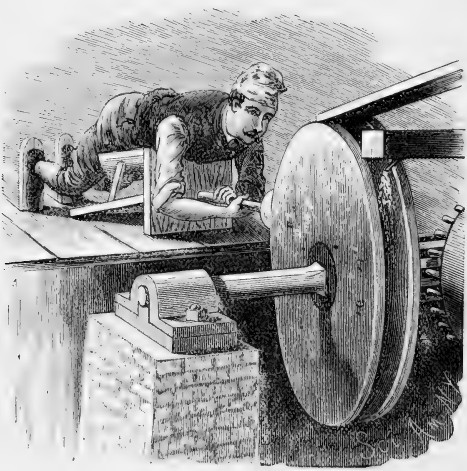
The crystal then being in a spherical form, but with its exterior rough, is handed to a grinder, who has a number of cylindrical pieces of cast iron, about 1 foot in length, and resembling reversed graters, which are of different thickness and variously curved according to the size of the crystal to be ground. The grinding material consists of powdered garnet and emery, fine or coarse, as required. Water is used plentifully, and the ball is dexterously kept turning, so that the surface is made perfectly spherical. In some cases, the ball is fixed in the end of a bamboo tube and kept whirling in the hand of the workman until it is smooth. The perfect polish desired can only be produced by patient rubbing, first with the tip of a bamboo cane and then with the hand, dipped in rouge (hematite), which gives a splendid lustrous surface. The perfect *tama* (jewel ball) is then ready for its wavy throne of bronze or its nest of satin. A favorite native proverb is: "Until polished, the precious gem has no splendor."

This method of manufacture is very laborious and slow, and, were it not for the cheapness of labor, it would be a very serious item.

In Germany, France, and the United States, the balls are not made by hand as in Japan, but the piece of crystal is placed in a semi-circular groove, worn in huge grindstones either by a piece of flint or a crystal pebble, and held there while the stone is revolved, until, in a short time, it assumes a shape the exact counterpart of the semi-circular groove in the grindstone. Care is required during this operation not to allow the wheel to become dry, but to keep it constantly wet, since the friction will soon heat the crystal, and, if water is then put on the wheel, the crystal is liable to crack, just as it does if it is heated and then dipped into water.

The polishing is then done on a wooden wheel with tripoli, or else on a leather buff with tripoli or hematite. By this method, which has been in use from the latter part of the sixteenth century, or even earlier, up to the present day, crystal balls have been manufactured without the requisition of more skill than that necessary in turning out a common semi-circular piece of agate for a bracelet or other ornament.

The crystal cups, vases, pitchers, and other similar objects of the sixteenth and seventeenth centuries now in the Louvre, the Dresden Green Vaults, and the Schatzkammer of Vienna, are infinitely superior to any such simple work as these spheres of crystal. Many of them are to-day faithfully reproduced in Vienna, a number having found a ready sale in the United States



Methods of working rock-crystal, agate, etc., in Germany, France, and United States.

during recent years. Two fine examples of this class were in the Morgan collection. They are crystal dishes, measuring from 4 to 6 inches across, beautifully engraved in intaglio, and mounted in silver and gems, and are as rich as the originals in the Vienna collection.

Many small crystal objects of foreign manufacture, such as spectacles and small balls of $1\frac{1}{2}$ inches diameter, can be purchased in New York, notwithstanding duty, cheaper than they can be cut here, unless a large order is given. There are regular quotations by which balls can be ordered from the Oberstein factories.

Three parties in the United States have machinery, such as is used in the crystal-cutting works of the Oberstein district, and are prepared to manufacture perfect spheres of rock-crystal, from furnished material, at the following average prices: 1 inch diameter, $1; 2 inches diameter, $5 to $8; 3 inches diameter, $15 to

Largest crystal ball in the United States, 6⅝ inches in diameter.

Japanese crystal ball on bronze stand representing crest of waves.

Russian vase of rock-crystal, 5 inches high.

$25; 4 inches diameter, $40 to $75; 5 inches diameter, $125 to $150; 6 inches diameter, $200 to $300; 7 inches diameter, $300 to $400.

A crystal sphere 6⅝ inches in diameter would lose in recutting, in order to remove a "bulb of concussion," one-fourth of an inch. The estimated cost of recutting such a sphere was, in New York \$50 to \$75, and in Japan \$50.

The facilities for working hard stone in the Oberstein Idar, in Oberstein, are so good that a dish of agate, 13 inches long, 8 inches wide, and over 3 inches deep, and hollowed out to $\frac{1}{8}$ inch in thickness, was sold for \$200 in New York after passing through the hands of three dealers, and paying a duty.

The $6\frac{1}{4}$-inch ball hereafter quoted as weighing 15 lbs. Troy, was offered for sale at \$400, and the cost of cutting it was probably not more than one-fourth of that amount. It will thus be seen that at Oberstein it is not the cost of the turning of rock-crystal into spheres that is the cause of the high prices, but simply the *extreme rarity of masses of rock-crystal which will afford absolutely pure spheres from* $3\frac{1}{3}$ *inches in diameter upwards.* The great rarity of these masses and the constant demand, which at all times has been greater than the supply, warrant the prediction that prices will be higher rather than lower. The United States, with its host of collectors of fine Japanese pottery, bronzes, and other curios, who do not hesitate to spend thousands of dollars for a single object, cannot boast of the possession of half a dozen perfect crystal balls over 5 inches in diameter.

Dealers themselves are often ignorant of the true reason why crystal balls are so expensive, and being interrogated on this point, may answer that the difficulty of cutting them is the cause of the high price at which they are held.

Among the French crown jewels is a crystal ball measuring $6\frac{1}{2}$ inches in diameter. One in the possession of Mr. R. E. Moore measures $6\frac{5}{8}$ inches in diameter, and is valued at \$5,000. This ball was purchased in Japan twenty years ago for \$4,000. Mr. Samuel M. Nickerson, President of the First National Bank of Chicago, owns a fine ball measuring $5\frac{5}{8}$ inches in diameter, and valued at \$2,500, which was brought to this country by Commodore Perry. In the possession of Mr. Brayton Ives is one measuring $5\frac{5}{8}$ inches, estimated to be worth \$3,000; and Mr. Heber R. Bishop has one measuring $5\frac{7}{8}$ inches in diameter, which was sold for \$1,250 at a New York sale. Mr. W. D. Walters, of Baltimore, owns another measuring $5\frac{3}{4}$ inches in diameter; Mr. Pruyn, of Albany, one $5\frac{1}{2}$ inches in diameter; and Mr. James F. Sutton, of New York, one $5\frac{5}{8}$ inches in diameter. A crystal ball in the Harper collection, measuring $4\frac{1}{2}$ inches, was sold last week to Mr. Hiram J. Sibley for \$1,600, while one of exceeding purity in the Morgan collection was $4\frac{1}{2}$ inches in diameter, mounted on a silver stand ornamented with a gold dragon and other grotesques, and containing the private, or palace seal of the Mikado. It sold for \$1,750, and the stand alone was estimated to be worth \$800.

During the preparation of two articles on precious stones for the Geological Survey, the writer had occasion to examine almost all our public and private collections, and to write hundreds of letters of inquiry on the subject of American gems and gem minerals, but has so far failed to learn of any masses of rock-crystal in the United States that would produce *a perfect three-inch ball.* (See page 550, "Mineral Resources of the United States," 1883–1884.)

Several pieces that would have afforded balls from three to four inches in diameter were brought to light, but they were so filled with veinings that the material had been used for other purposes. A ball measuring two and a quarter inches in diameter was cut for the writer in August, 1885, which, although beautiful, was not perfect internally.

The rarity of large masses of pure crystal is such that a well-known dealer has a standing offer of one thousand dollars for a five-inch crystal ball, fifteen hundred dollars for a five and a half-inch ball, and four thousand dollars for a seven inch-ball. It is said that these prices are only one-third of what they are worth in Japan.

The New York representative of a Japanese trading company received the following response on sending an order for crystal balls to Japan: "None produced. None of any size for sale. Have an offer of three thousand dollars for a perfect four and a half-inch ball."

After extended inquiry in New York, London, Paris, and other large cities, as well as in Japan and Brazil, the writer concludes that crystal balls or material to furnish them from one to three inches in diameter can at any time be procured from either Japanese, Madagascar, Swiss, or Brazilian rock-crystal. Several tons of material that would furnish balls from one to three inches in diameter have been recently sent to this market from Brazil, because the foreign markets are glutted with balls of these sizes. An order which was given out some years since for crystal slabs measuring four by six and five by six inches, and from one-quarter to one inch in thickness, has remained unfilled to this day, although it is well known to dealers both in this country and in the principal European markets.

Rev. C. W. King mentions, in "Antique Gems," p. 93, having seen a rolled crystal over one foot in length, of a perfect egg shape and of admirable transparency, which was part of the plunder of Delhi.

Imperfections in rock-crystal are usually small seams or flecks of white clouds, produced either by fracture, inclusions of impurities, or, as is often the case, microscopic cavities filled with liquid carbonic-acid gas or water. Another imperfection is the "bulb of concussion," as it would be termed by archæologists. This is produced whenever a mass of crystal or agate receives a sharp blow from being dropped on the floor, struck forcibly with a mallet, or from other cause; a funnel-shaped flaw is produced, the small end being at the surface of the crystal. If no further blow be given, the flaw may still develop toward the interior of a crystal. Bulbs of concussion can be seen in any agate mortar that has been extensively used in the laboratory. Dozens have been observed in a single mortar. In the breaking of flint, this same structure is developed.

It might be possible for a ball containing one or more of these bulbs of concussion to be polished on a sand-stone wheel, as is done at Oberstein, but the flaws are likely either to develop toward the centre of the mass, or else flake off to one side and ruin the entire crystal.

To determine whether a crystal is perfectly spherical, it should be put into a bath of mercury. The lightest part will always come to the top.

The Japanese occasionally deceive unsuspecting persons by selling to them glass imitations of crystal. A single glance would be sufficient to detect the fraud, if the purchaser had ever seen a pure, pellucid crystal ball, since it is impossible to produce such a large piece of glass entirely colorless. If the imitation ball is placed beside a genuine crystal, the difference is at once apparent.

The following is a table of the weights of crystal balls of different sizes:

	LBS.	OZ.	DWT.	GRS.
25 mm. or 1 inch,	—	—	14	—
35 " " $1\frac{3}{8}$ "	—	1	18	—
40 " " $1\frac{5}{8}$ "	—	3	—	9
45 " " $1\frac{13}{16}$ "	—	3	13	12
54 " " $2\frac{1}{8}$ "	—	7	1	12
64 " " $2\frac{9}{16}$ "	—	12	10	—
$3\frac{1}{2}$ "	1	6	—	—
$6\frac{1}{4}$ "	15	—	—	—

Most of the rock-crystal used to-day comes from Madagascar and Brazil. Friedeberg, Salzburg, Zillerthal in the Tyrol, Hungary, and Ceylon contribute more or less sparingly to the general supply; North Carolina, California, and other American localities furnish some material which is rarely used, owing to the small size of the crystals and the cheapness of the foreign mineral.

In 1735 the yield from the Cave of Zinkenstock, near the Grimsel, was valued alone at £2,250. It is also found in small quantities at Jochle Berg, in the same region.

Fischbach in Visperthal afforded the crystal for the pyramid of Marsfeld, made in 1797. This block, which is a cluster measuring three feet in diameter and weighing over eight hundred pounds, is now in the Museum of Natural History, at Paris.

The neighborhood of Mt. Blanc yields beautiful, clear crystals, the preparation of which for sale gives lucrative employment to the inhabitants of the vale of Chamouny.

At Galenstock, above the Tiefengletscher, a most remarkable deposit was found in a granite cave, which yielded over one thousand crystals of from fifty to three hundred pounds' weight, but unfortunately of a smoky color. The finest of these crystals, weighing one hundred and twenty-five pounds, and called the *President*, is in the celebrated collection of Mr. Clarence S. Bement, of Philadelphia. Of the others, perhaps the best are at Berne, Switzerland—one called the *Grandfather*, weighing two hundred and seventy-six pounds, and another, known as the *King*, of two hundred and fifty-five pounds' weight.

A crystal of thirty-eight centimetres in height and nine centimetres in diameter, from Savoy, is now in the Dresden Green Vaults.

In Japan, nineteen mines are now being worked for quartz and rock-crystal. The latter material is found in large clear masses in the mountains on the Island of Niphon, Fusiyama, and in the granitic rocks of central Japan, the principal veins being near Kami; but is also found among the gravel beds, where transparent masses that would furnish perfect spheres six inches in diameter have been dug out. Some suppose, however, that much of the Japanese crystal is procured from China, and, from statements made to the writer by members of the Corean Embassy that recently visited us, it seems probable that the peninsula of Corea has furnished some of the material for these Japanese objects. It was further learned that there are at present twelve workers of crystal in Corea.

June 7, 1886.

Regular Business Meeting.

The President, Dr. J. S. Newberry, in the chair.

Twenty-five persons present.

Mr. Walter W. Law and Mr. John Murray Mitchell were elected Resident Members.

Mr. George F. Kunz exhibited crystals of gold, in strings and elongated octahedrons, from the Ontario Mine, Colorado.

The Secretary, PROF. H. L. FAIRCHILD, stated that the number of subscriptions already received for the "History of the Society" justified its publication. The character, plan, style, and illustrations of the book were described.

The following Memorial notices were read by PROF. D. S. MARTIN.

The Committee appointed to prepare a minute respecting the death of Mr. Thomas Bland, submit the following report:

Mr. Thomas Bland.

In the death of our eminent and accomplished associate, Mr. Bland, the Academy has met with an irreparable loss. Though during the later years of his life he was very rarely present at our meetings, owing to his feeble health and his Brooklyn residence, and was therefore little known to the recent members of the Society, yet his interest in it was unabated, and his valuable work as a contributor to the Annals continued until but a short time since. In the earlier, or rather the middle period of the Society's history, he was one of its most active supporters and attendants, and for many years he was at the head of its Publication Committee. As my predecessor in that office, I was brought much into relation with him, and owe to his kindness and his experience much that I highly prize.

Thomas Bland was born in England in 1809; he had reached, therefore, the well-advanced age of seventy-six, when he died in August last. He was the son of a physician of the same name, and of a mother whose taste for science, and collections in natural history, early gave him that direction of mind which bore rich fruit in the scientific studies of his maturer years. He was educated at the "Charter House School," in London, and had for one of his classmates the celebrated novelist Thackeray. At first, he studied law; but in 1842 he went to the West Indies, and remained for eight years, chiefly in Barbadoes and Jamaica, engaged in business, and studying and collecting in natural history. He there formed the acquaintance of the accomplished and lamented Prof. C. B. Adams, of Middlebury College, Vermont, an acquaintance that became a firm and strong friendship until the death of Adams three years later. This association tended greatly to quicken and strengthen his already marked scientific interest. He then accepted the superintendency of a mine in New Granada, and after residing there two years, came to this city, and made it his permanent abode.

Soon after coming to New York and entering into business, he was introduced, in 1852, into the Lyceum of Natural History. In such kindred spirits and co-laborers as our members Redfield and Wheatley, Mr. Bland soon found the same sympathy and stimulus as he had previously enjoyed with Adams. Here began his career of study and publication, in connection with this Society, which continued for over thirty years. No less than seventy-two papers, many of them extensive articles, have come from his busy pen. In later years, he became engaged with Mr. W. G. Binney, Jr., in the preparation of their great joint work on "The Terrestrial Molluscs of North America."

With a broad general interest in science, Mr. Bland possessed great familiarity in his own especial branches, conchology and geology, particularly the land-shells of America and the West India Islands, and the geology of the latter region. In these departments, there is probably no one living in this country who can rank as his superior or even his equal, perhaps not even in the world.

Of Mr. Bland's personal qualities, I can say but little here. Those who knew him need not to be reminded of his cordiality, his suavity, his kindliness, or his upright life and character. It would seem as though these qualities, that gave such a charm to his social intercourse, must have been long recognized as an ancestral trait; for Mr. Bland once showed me the old family bearings, with the motto (Prov. xv. 1) "Responsio blanda iram avertit."

It is a very touching memory to me, that after several unsuccessful attempts to see him, in the last months of his physical and mental decline, I was able to meet him for a short time on the 20th of August last. Though his memory was impaired, and his frame decrepit, his mind was clear, and his smile of kindly welcome peculiarly attractive and cordial. After a brief interview of pleasure mingled with sadness, we parted with much warmth of feeling, hoping, though, of course, doubting, to meet again. As I learned some time later, Mr. Bland departed before another day.

DANIEL S. MARTIN,
for the Committee.

The Committee appointed to prepare a minute respecting the death of Dr. A. C. Post, submit the following report:

Alfred Charles Post, M.D.,

was born in this city in 1806, and died on the 7th of March last at the age of eighty years. He was a true New Yorker, his father having occupied the beautiful Claremont property, now celebrated in connection with the burial-place of Gen. Grant, in Riverside Park; while his own entire life was passed in the city of his birth, save for very brief intervals of absence. He entered Columbia College before he was fourteen, and graduated in medicine at the age of twenty-one from the College of Physicians and Surgeons. To perfect his medical training, he then went abroad, and spent two years in study at several of the leading capitals of Europe. On his return, he established himself in New York, and with the exception of two years (1835–37) in Brooklyn, this city was his life-long home.

Dr. Post's professional career has been an honor to himself and to the metropolis. He early developed especial interest and aptitude in the department of surgery, and became largely a specialist in that branch of practice. He was one of the founders of the medical department of the New York University, and after its organization he became professor of surgery therein from 1851 to 1875. He was also president of the Medical Faculty of the University from 1873 till the time of his death. During the war, Dr. Post made an extended tour of the military hospitals, a tour full of interest and fruitful in good results. He was connected with many professional societies, both here and in Europe; was President of the New York Academy of Medicine in 1867–68, and Vice-President of the American Medical Association.

Dr. Post's connection with this Society dates from his election in 1876 to his resignation in 1885. He was a frequent attendant at the meetings of the Academy during the earlier part of his membership, until he began to feel somewhat the increasing weight of years. For much of this time he was a member of the Council, and his calm judgment and sound, though modest advice were always trusted and honored. He was Vice-President of the Academy in 1884–85.

Of his family of eleven children, one son in particular has shown the same scientific and professional tastes as his father, and has already won an eminent name—Prof. George E. Post, of Beyrout, Syria, the missionary and scientist, and professor of surgery in the medical department of the Protestant College in that city. The departure of this son to Syria, and his great success in introducing in the East the finest forms of our American Christian science and culture, naturally led Dr. Post to feel a profound interest in that work. An earnest and devout Christian believer through all his career, and an elder in the Presbyterian Church of the Covenant, he now became the President of the New York Medical Missionary Association.

Dr. Post was a man of dignified and kindly manner, and great simplicity of character and address. His bright, intellectual countenance, with its silver framing of hair and beard, bore a decided resemblance to Wm. Cullen Bryant. His mind was active to the last; and he leaves a record identified with all that is best in the society of our city, and all that is pure and honorable in private life and character. DANIEL S. MARTIN,
for the Committee.

DR. J. S. NEWBERRY read by title a paper:

NOTICE OF FOSSIL FISHES OF THE CHEMUNG AND CATSKILL.

(To be published in the Annals, Vol. IV., No. 1.)

ACADEMY adjourned to the first Monday in October.

The LIBRARIAN reported the following

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